GEOSYNTEC CONSULTANTS

Carus Chemical SF/Tech

15 January 1996

EPA Region 5 Records Ctr.

211120

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IEPA/DLPC

Mr. Timothy Murphy
State of Illinois
Environmental Protection Agency
2200 Churchill Road
Springfield, Illinois 62794-9276

Subject: Transmittal of Phase II Site Investigation Report
Carus Chemical Company Site

Dear Tim:

Enclosed are six copies of the above-referenced report for your review and comment. On behalf of the Carus Chemical Company, GeoSyntec Consultants (GeoSyntec) would like to meet with you to discuss the findings presented within the report. I will call you within the next couple of weeks to see if we can set up an appointment.

In the meantime, please feel free to call me if you have any questions regarding the enclosed report.

Sincerely,

J Andrew Mattyon for

Nandra D. Weeks, P.E.
Project Manager

Copies to: Roger Threde (Carus Chemical Company w/one copy of report)
Mark Sargis (Mauck, Bellande & Cheely w/two copies of report)

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COPY

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Prepared for

carus
CHEMICAL COMPANY
1500 Eighth Street
LaSalle, Illinois 61301

PHASE II SITE INVESTIGATION

COMPLETION REPORT

CARUS CHEMICAL COMPANY MANUFACTURING FACILITY

LASALLE, ILLINOIS

VOLUME 1

Submitted to

State of Illinois
Illinois Environmental Protection Agency
2200 Churchill Road
Springfield, Illinois 62794-9276

Prepared by

GEOSYNTEC CONSULTANTS
621 N.W. 53rd Street, Suite 650
Boca Raton, Florida 33487

GeoSyntec Consultants Project Number FE2167

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LIST OF ACRONYMS

BNA	Base/Neutral and Acid Extractable Organic Compounds
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
HRS	Hazard Ranking System
ICRR	Illinois Central Railroad
IEPA	Illinois Environmental Protection Agency
IHWMR	Illinois Hazardous Waste Management Regulation
ISA	Integrated Site Assessment
M&H	Matthiessen and Hegeler
MSL	Mean Sea Level
NCP	National Oil and Hazardous Substances Pollution Contingency Plan
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
NTU	Nephalometric Turbidity Unit
PA	Preliminary Assessment
PAH	Polynuclear Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyl
POTW	Publicly Owned Treatment Works
Pre-Notice Program	Pre-Notice Site Cleanup Program
PSI	Preliminary Site Investigation
RCRA	Resource Conservation and Recovery Act
SSI	Screening Site Inspection
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound

INTRODUCTION

1. INTRODUCTION

1.1 Overview

Carus Chemical Company is conducting a remedial investigation of its manufacturing facility and associated property located in LaSalle, Illinois (Figure 1-1). This work is being performed under the supervision of the Illinois Environmental Protection Agency (IEPA) under the Pre-Notice Site Cleanup Program (Pre-Notice Program). For the purpose of effective project management, this investigation is being conducted in phases. In general, each phase covers a particular geographic area of the Carus Chemical Company site.

Three major investigations have been conducted by GeoSyntec Consultants (GeoSyntec) on behalf of Carus Chemical Company since 1992. The investigations have been referred to as: (i) the Preliminary Investigation, conducted in the Fall of 1992, prior to entering the Pre-Notice Program; (ii) the Phase I Investigation, conducted in the Fall of 1993; and (iii) the Phase II Investigation, conducted in the Fall of 1994. Phase I and II refer to geographical areas, as shown in Figure 1-2, rather than levels of investigation. The Phase I Area geographically consists of the Carus Chemical Company manufacturing facility located at 1500 8th Street, in the northwest corner of Section 14 and in northeast corner of Section 15 of Township 33 North, Range 1 East of the Third Principal Meridian in LaSalle County, Illinois (Figure 1-1). The Phase II Area Investigation geographically consists of the area adjacent to and located just east of the Carus Chemical Company manufacturing facility in Section 14 of the same township and range. The Phase II Area includes from west to east: (i) the eastern embankment of the manufacturing facility; (ii) a segment of the Illinois Central Rail Road (ICRR) embankment; (iii) the southern part of the slag pile; (iv) a holding pond; and (v) a segment of the Little Vermilion River.

Carus Chemical Company has retained GeoSyntec to perform technical work for the remedial investigation of the Phase II Area. Hereinafter, this work will be known as the Phase II Investigation. The Phase II Area consists of the area adjacent to and east of the main plant area of Carus Chemical Company. The results of the Phase II Investigation are provided within this document titled "*Site Investigation of the Phase*

II Area, Carus Chemical Company Manufacturing Facility, LaSalle, Illinois", along with a summary of results from prior investigations.

The following work has been performed under the direction of GeoSyntec during the Preliminary Investigation, Phase I Investigation, and Phase II Investigation:

- 52 borings have been advanced into the subsurface, totaling 1,515 ft (462 m) of penetration;
- 38 soil or slag samples have been obtained and analyzed;
- 25 ground-water samples have been obtained and analyzed;
- the Little Vermilion River has been investigated through measuring flow along four transects and obtaining and analyzing five river sediment samples and three river water samples; and
- the holding pond has been investigated through profiling four transects and obtaining and analyzing three sediment samples (GeoSyntec notes that the surface-water quality is routinely monitored through a National Pollutant Discharge Elimination System (NPDES) permit).

This work is summarized by investigation in Table 1.1 and does not reflect samples obtained for quality control purposes. The site investigations of the Phase I and Phase II Areas were conducted under the Pre-Notice Program in accordance with IEPA-approved work plans. These investigations yielded valuable data with regard to the environmental, hydrologic, and hydrogeologic settings of the properties, and were performed following Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and IEPA protocols.

1.2 Purpose and Scope of Phase II Investigation

The purpose of the Phase II Investigation is to evaluate suspected contamination previously identified by the IEPA in the Phase II Area in order to: (i) characterize the nature and extent of chemical constituents in the Phase II Area of the site; (ii) determine the impact on ground water and the Little Vermilion River; (iii) identify the potential sources of any such impact; and (iv) satisfy the requirements of the Pre-Notice Program. The results of this investigation will be used to establish risk-based cleanup levels and to evaluate possible remedial alternatives consistent with applicable standards under CERCLA.

To accomplish these purposes, the Phase II Investigation has four main objectives:

- to characterize the nature and extent of suspected "hazardous substances", as defined in Section 101(14) of CERCLA, and as previously identified by the IEPA;
- to determine the relationship between various industrial deposits (e.g., slag) and suspected "hazardous substances";
- to determine the relationship between the industrial deposits and water resources for the area; and
- to perform all work in accordance with applicable requirements and standards established by the United States Environmental Protection Agency (USEPA) and the IEPA.

The scope of work for the Phase II Investigation was approved by the IEPA and included field work, laboratory work, data evaluation, and report preparation. The field work consisted of the following general activities: (i) drilling and piezometer installation; (ii) hydrogeologic testing; (iii) collection of soil, sediment, river, and ground-water samples for chemical analysis; and (iv) general geologic observations. The laboratory work consisted of analyzing the samples for selected constituents, including the previously identified hazardous substances. The data evaluation included compilation and analysis of field and laboratory data. Report preparation included preparation of this document.

1.3 Report Organization

The remainder of this report is organized as follows:

- Section 2 presents background information;
- Section 3 presents the field investigation performed for the Phase II Investigation, including objectives and methodologies;
- Section 4 provides a discussion of the hydrogeologic findings of the investigation;
- Section 5 presents the chemical findings of the investigation;
- Section 6 provides a discussion of the Phase II Investigation results; and
- Section 7 presents the conclusions and recommendations based on the results of the investigation.

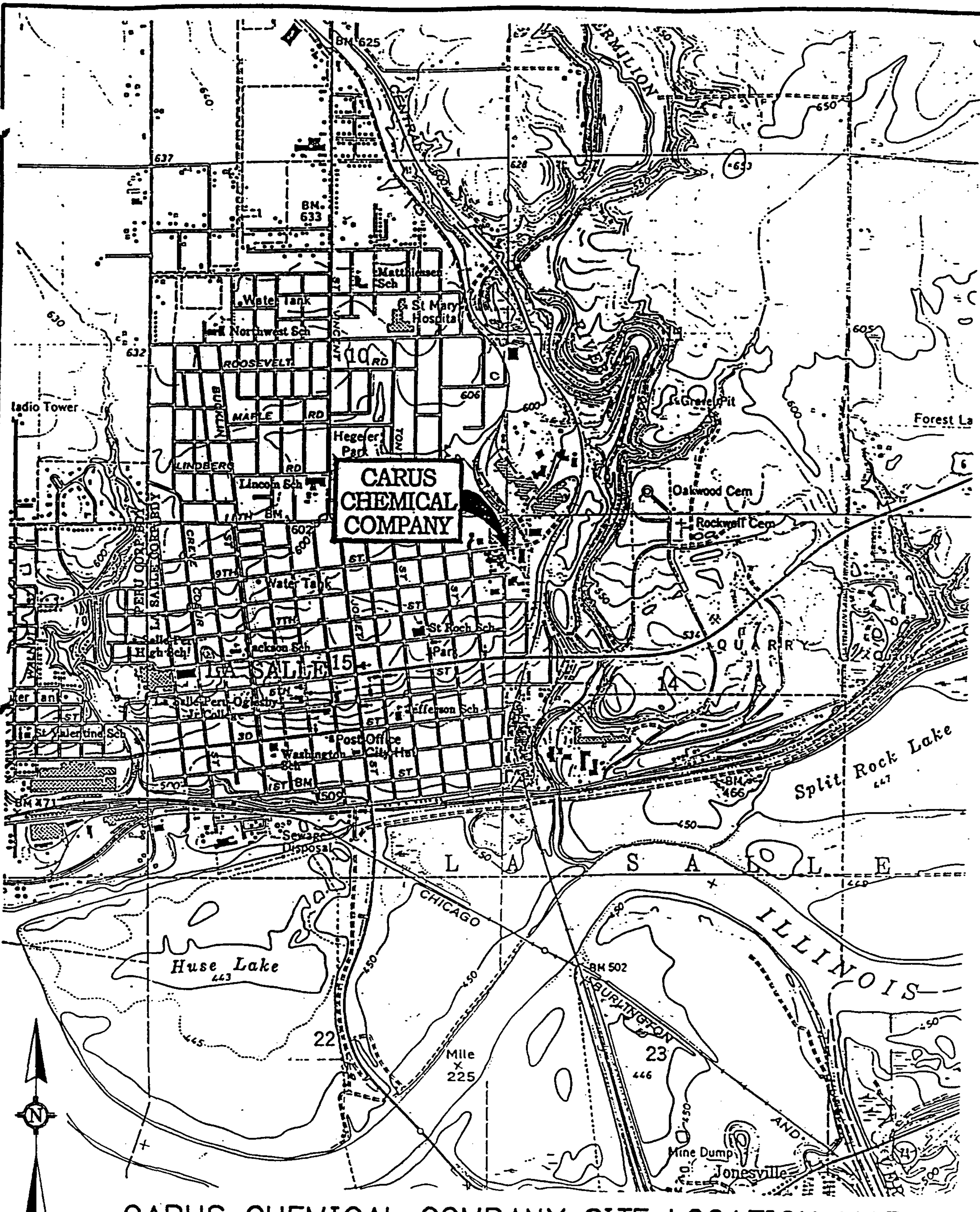
Tables and figures are provided at the end of each section where referenced. Drawings are provided at the end of the report before the appendices.

Table 1.1 Summary of Fieldwork Completed to Date by GeoSyntec

Work Element	Preliminary Investigation	Phase I Investigation	Phase II Investigation	Total
Soil Borings	16	18	18	52
Soil/Slag Samples[1]	4	16	18	38
Ground-Water Samples	5	8	12	25
River Sediment Samples	2	-	3	5
River Water Samples	-	-	3	3
Holding Pond Sediment Samples	-	-	3	3

1 Includes samples obtained for chemical analysis. A larger number of samples was obtained for visual description and classification.

General Note: Numbers do not include samples obtained for quality control purposes.

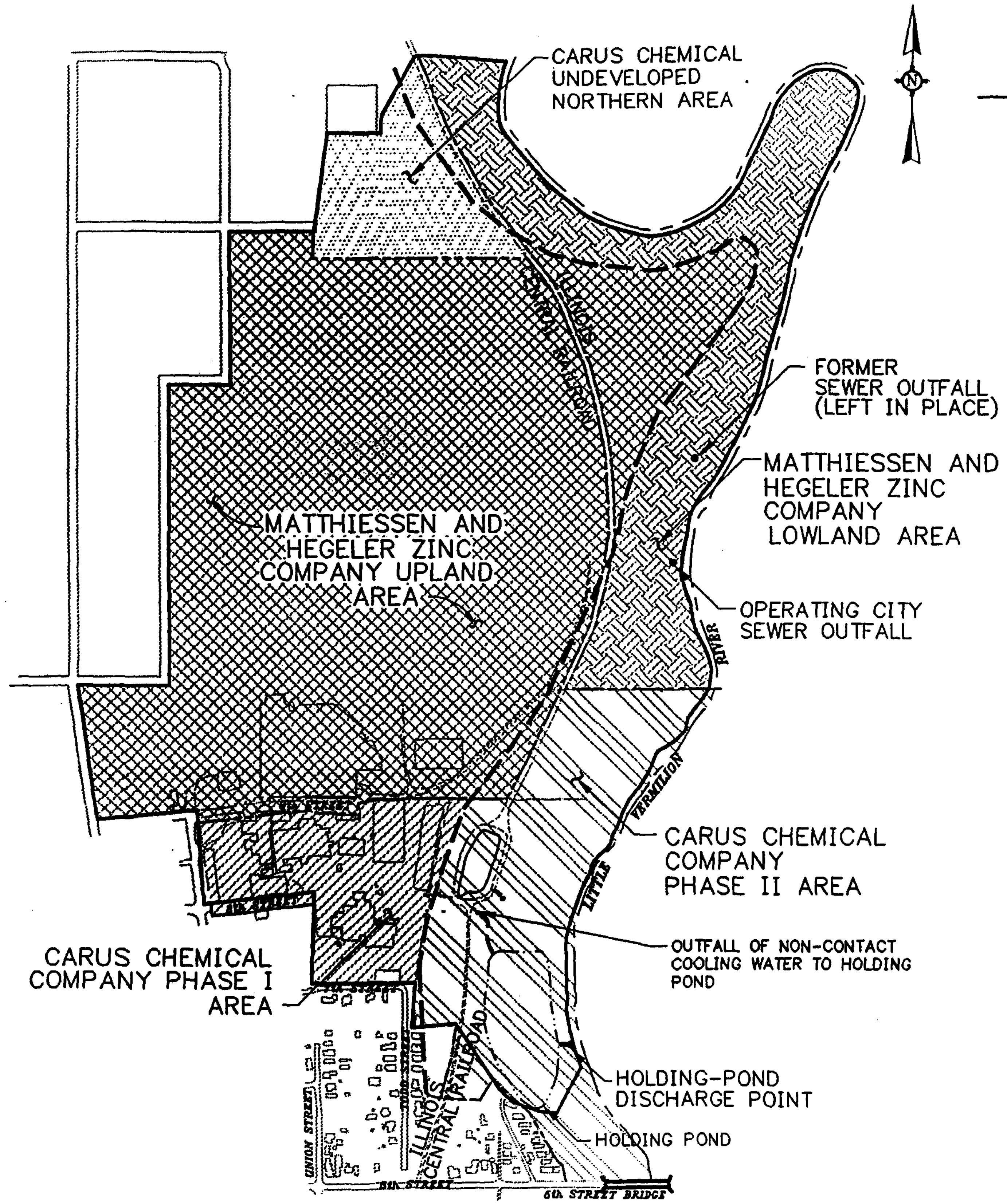


CARUS CHEMICAL COMPANY SITE LOCATION MAP

GeoSyntec Consultants

FIGURE NO.	1-1
PROJECT NO.	FE2167
DOCUMENT NO.	
PAGE NO.	

2167F002 199601081609MR



0 300 600

1 inch = 600 ft.

N

LEGEND

— - —	RIVER
-·-·-·-	HOLDING POND
— — —	TOP OF BLUFF
—·—·—	PROPERTY BOUNDARIES
(pattern)	CARUS CHEMICAL COMPANY PHASE I AREA
(pattern)	CARUS CHEMICAL COMPANY PHASE II AREA
(pattern)	FORMER MATTHIESSEN AND HEGELER ZINC COMPANY OPERATIONAL UPLAND AREA
(pattern)	FORMER MATTHIESSEN AND HEGELER ZINC COMPANY OPERATIONAL LOWLAND AREA
(pattern)	CARUS CHEMICAL COMPANY UNDEVELOPED NORTHERN AREA

NOTES:

1. WELL AND FEATURE LOCATIONS TAKEN FROM DECEMBER 1994 CHAMLIN SURVEY.
2. LOCATION OF LITTLE VERMILION RIVER ESTIMATED BY SURVEYOR FROM OBSERVATIONS AND MAPS.
3. OUTLINES OF FEATURES IN PHASE II AREA ESTIMATED FROM AIR PHOTO AND MAP INTERPRETATION.
4. MATTHIESSEN AND HEGELER ZINC COMPANY CERCLIS SITE BOUNDARY ESTIMATED FROM AIR PHOTO AND MAP INTERPRETATION.

AREAS OF INVESTIGATION

GEOSYNTEC CONSULTANTS

FIGURE NO.	1-2
PROJECT NO.	FE2167
DOCUMENT NO.	
PAGE NO.	

2167F014 199601081622MR

BACKGROUND

2. BACKGROUND

2.1 Site Description

The Carus Chemical Company manufacturing facility is located within the City of Lasalle, Illinois. In general, the area consists of a flat upland area with an average elevation of between 650 to 750 ft (200 to 230 m) (1929 National Geodetic Datum). The facility lies at an elevation of approximately 580 ft (180 m), except near the eastern boundary of the site, where the elevation decreases to approximately 460 ft (140 m) at its boundary with the Little Vermilion River. The Little Vermilion River flows south from the facility for approximately 1 mi (1.6 km) where it intersects with the Illinois River. The Illinois River Valley divides LaSalle County into approximately two equal sections. The Illinois River Valley is approximately 1 mi (1.6 km) wide in the City of LaSalle, with relatively steep bluffs approximately 150 ft (46 m) high.

The temperature in the City of LaSalle varies between approximately 18°F (-8°C) in January to 86°F (30°C) in July. Mean annual rainfall is approximately 34 in. (860 mm). The prevailing wind is from the south with an average velocity of 11 mph (18 km/h).

Prior to the present land use, the Phase II Area was located within the Little Vermilion River Valley, with land uses consisting primarily of: (i) agriculture (on top of the slope valley); and (ii) industry (Grist Mill, ICRR and a related round house, and Kentucky mine railroad), as seen on a 1876 survey plat (Figure 2-1).

2.2 Industrial History of the Area

A historical overview of the Carus Chemical Company and adjacent property to the north (i.e., the former Matthiessen and Hegeler (M&H) Zinc Company) has been developed based on: (i) review of available plat surveys of the surrounding area from 1876 to 1925 (obtained from the LaSalle County Historical Society); (ii) historical photographs from 1939 to 1988 (obtained from the University of Illinois at Urbana-

Champaign); (iii) site topographic maps; and (iv) interviews with individuals familiar with historical site operations. The historical overview is provided below:

- Based on the plat survey, in 1876, a large portion of the property owned by Carus Chemical Company was likely used for agricultural purposes. Property owners included: (i) Zinc Rolling Mills, northwest of the ICRR; (ii) F. Gray, in the Little Vermilion River Valley area; (iii) ICRR for the rail road and a round house located southwest of the Phase II Area; and (iv) small lots west of the ICRR owned by various individuals. The largest portion of property was owned by F. Gray. This property included the Grist Mill and several other buildings. The Grist Mill was constructed on an island between a large river arm (likely to be the Little Vermilion River bed enlarged by a dam regulating the river flow) and a narrow river arm (likely to be artificially excavated). The large river arm was almost entirely located on the property investigated during the Phase II Investigation. The Little Vermilion River flowed from its present location north of the slag pile, toward the south-southwest where the holding pond is presently located, and then toward the southeast.

- In the mid-1800s, the M&H Zinc Company (currently operated as LaSalle Rolling Mills), located at 900 Sterling Street, north of the Carus Chemical Company manufacturing facility, began operations primarily as a zinc processing facility. (Any reference to LaSalle Rolling Mills in this report is meant to be a generic reference to all current and prior entities which operated on the property, including M&H and Zinco, another successor to M&H). Zinc ore was imported to the LaSalle Rolling Mills property where it was refined, recovered, and rolled for industrial use. By-products, including sinter, slag, and other off-specification materials, were placed south and east of the LaSalle Rolling Mills main plant in the area between the plant and the Little Vermilion River. Portions of the slag and sinter disposal areas were placed on property now owned by Carus Chemical Company.

- Based on the plat survey, in 1876 (Figure 2-1), a mine shaft (Kentucky Shaft) was located on the Northern Illinois Coal & Iron Company property (about 500 ft (152 m) north of the Phase II Area). Another coal mine shaft was present on the zinc rolling mill lot. Coal extracted from this mine was likely used in the furnaces for zinc smelting processes. Interviews with local residents indicated that this coal mine was dry while in operation.

- Based on the 1895 plat survey, a portion of the property owned by the Northern Illinois Coal & Iron Company was purchased by M&H Zinc Company.

- On the 1905 and 1906 plat surveys, no significant changes occurred. On the 1925 plat survey, Carus is shown as the property owner of the northwest quadrant of the present Carus Chemical manufacturing facility site. No other significant changes were noted on the plat survey.

- Based on 1939 aerial photograph, most of the slag had already been placed at its current location in the Phase II Area. Placement practices resulted in a diversion of the natural course of the Little Vermilion River.

- Based on the 1953 aerial photograph, a new river channel was noted downstream of the slag pile, east of the former river channel.

- Based on the 1958 aerial photograph, the Little Vermilion River was more prominent to the east of the slag pile, and joined the former river channel downstream of the site.

- Based on the 1961 aerial photograph, the holding pond had been constructed at the southeast corner of the Carus Chemical Company property. The holding pond accepted the discharge from the Carus Chemical Company manufacturing facility. The holding pond improved effluent handling methods and curtailed direct discharge of the effluent to the Little Vermilion River.

- Based on the aerial photographs, site interviews, and topographic maps, it appears that between 1961 and 1988, the holding pond berm was raised twice and the pond dredged at least once. In the 1988 aerial photograph, approximately 1,300 ft (400 m) of the slag pile's eastern edge was in contact with the Little Vermilion River.

- In 1991, Zinco merged with LaSalle Rolling Mills. LaSalle Rolling Mills currently performs operations involving smelting, rolling, casting, stamping, and plating of zinc, aluminum sheet, and wire products.

2.3 Site Histories and Operations

The manufacturing and business operations of the former M&H Zinc Company (and its successors, presently LaSalle Rolling Mills) and Carus Chemical Company have always been separate.

Carus Chemical Company began operation in 1915 manufacturing potassium permanganate products, used for water purification and wastewater treatment. Wastewater from potassium permanganate operations is classified as non-contact cooling water and is discharged to a holding pond at the south end of the Phase II Area. Water is discharged from the holding pond to the Little Vermilion River via a NPDES regulated discharge point. Process water from the pilot plant is treated on site and discharged to the publicly owned treatment works (POTW) of the City of LaSalle.

The M&H Zinc Company began zinc smelting and coal mining operations in about 1858. Other operations by the M&H Zinc Company included coking and production of sulfuric acid. Coal mining is believed to have ended on the M&H Zinc Company property around 1929 and zinc smelting during the 1960s. Some form of zinc operations continues today by LaSalle Rolling Mills, one of the successors to the M&H Zinc Company. Slag from zinc smelting continued to be dumped along the railroad tracks into the Little Vermilion River Valley throughout the life of the zinc smelter. Aerial photographs from 1939, 1953, and 1961 showed a large, expanding pile of slag in the Little Vermilion River Valley. Carus Chemical Company purchased most property containing this slag pile (primarily the Phase II Area) in 1973, after zinc smelting and slag generation ceased, but never implemented development plans or expanded operations in this area.

There has never been common ownership or operation of Carus Chemical Company and the former M&H Zinc Company, or its successor company, LaSalle Rolling Mills. The only points in common between the activities of the two corporations were:

- The former M&H Zinc Company disposed of slag and other fill material at the mouth of a small ravine in the east central portion of Carus Chemical Company Phase I Area.

- In 1973, Carus Chemical Company purchased the Phase II Area and the major portion of the northern undeveloped parcel of land (Apollo Warehouse Area) from the former M&H Zinc Company.

2.4 Regulatory History

Carus Chemical Company was listed in the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS) in August 1990 as a result of historical chemical manufacturing operations. The IEPA notified Carus Chemical Company, as owner and operator of the site, that the IEPA would investigate the site under the statutory authority of CERCLA. The IEPA performed a Preliminary Assessment (PA) at the Carus Chemical Company site in May 1991 and subsequently issued a PA report. On 20 and 21 November 1991, the IEPA conducted a CERCLA Screening Site Inspection (SSI), which included limited sampling and analysis of soil, sediment, and ground water to evaluate the chemical constituents at the site. The IEPA prepared a SSI report and calculated a preliminary Hazard Ranking System (HRS) score for the site. The IEPA's next step in the CERCLA process would have likely been to finalize the HRS score for the Carus Chemical Company site for possible inclusion on the National Priorities List (NPL).

Carus Chemical Company petitioned to enter the Pre-Notice Program in June 1993, primarily to prevent possible inclusion of its site on the NPL and associated administrative action, and to resolve potential liability under CERCLA. Because the site had not yet been scored for the NPL, the IEPA agreed that the Carus site was eligible for the Pre-Notice Program. Carus has maintained a good working relationship in completing the site investigations of the Phase I and II Areas of its property under the Pre-Notice Program. Work has progressed in accordance with standards and protocols consistent with CERCLA and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP).

The IEPA deferred further remedial investigations and activities under CERCLA, pending Carus Chemical Company's successful completion of work under the Pre-Notice Program. It is our understanding that the Carus Chemical Company facility site will remain in the CERCLIS as a result of the initial listing until one of the following conditions are met:

- all appropriate response actions have been performed; or
- the remedial investigation demonstrates that the site poses no significant threat to public health or the environment and, therefore, remedial measures are not appropriate.

The IEPA listed the M&H Zinc Company site separately under the CERCLIS in September 1993, after the IEPA had accepted the Carus Chemical Company site into the Pre-Notice Program. In November 1993, the IEPA conducted a SSI of the M&H Zinc Company site and, in January 1995, issued an Integrated Site Assessment (ISA) Report to document the investigation. The ISA Report did not incorporate any results from the investigations by the IEPA or by Carus Chemical Company of the Carus Chemical facility site. The IEPA and the Illinois Department of Public Health have planned further investigation of the M&H Zinc Company site, including additional sampling for off-site impacts to residential areas.

2.5 Previous Investigations

2.5.1 Introduction

Previous environmental investigations have been performed by the IEPA and by GeoSyntec at the Carus Chemical Company manufacturing facility and the adjacent M&H site in response to and consistent with applicable standards and requirements under CERCLA. These investigations are presented in the following documents:

- "*CERCLA Preliminary Assessment Report*", Carus Chemical Company, undated, prepared by the IEPA;
- "*CERCLA Screening Site Inspection Report*", Carus Chemical Company, prepared by the IEPA;
- "*CERCLA Preliminary Assessment Report*", M&H Zinc Company, undated, prepared by the IEPA;
- "*CERCLA Integrated Site Assessment*", M&H Zinc Company, undated, prepared by the IEPA;
- "*Preliminary Site Investigation Report*", Carus Chemical Company, June 1993, prepared by GeoSyntec; and
- "*Phase I Site Investigation Completion Report*", Carus Chemical Company Manufacturing Facility, LaSalle, Illinois, January 1994, prepared by GeoSyntec.

An overview of the investigations completed for the Carus Chemical Company and M&H sites is provided below. Investigations completed by the IEPA are presented first in chronological order followed by investigations completed by GeoSyntec on behalf of the Carus Chemical Company in chronological order. Figure 2-2 presents sampling locations for the investigations conducted by the IEPA; Figure 2-3 presents sampling locations for the PA and Phase I Investigation conducted by GeoSyntec.

2.5.2 CERCLA PA/Carus Chemical Company

The CERCLA PA was prepared by the IEPA sometime following placement of the Carus Chemical Company manufacturing facility in the CERCLIS in May 1991. The purpose of the PA was to conduct an initial evaluation of the site and recommend to the USEPA a priority for conducting additional investigations as part of the CERCLA process, as requested by the USEPA.

Based on the lack of any documented evidence of environmental damage, the safety record for the Carus Chemical Company, and the efforts taken by Carus Chemical Company to prevent releases and contain releases should they occur, the IEPA assigned a low priority to the site and recommended to the USEPA that a CERCLA SSI be conducted "as time allows".

2.5.3 CERCLA SSI/Carus Chemical Company

On 20 and 21 November 1991, the IEPA conducted a CERCLA SSI at the Carus Chemical Company manufacturing facility as the next step in the CERCLA process. The purpose of the SSI was to: (i) collect additional data in order to perform a preliminary HRS site score; (ii) establish priorities among sites most likely to qualify for the NPL; and (iii) identify the most critical data requirements for any further investigation, if necessary.

The SSI report provided a summary of activities at the site, including manufacturing processes, disposal practices, and current activities. The report also presented and discussed results of soil, sediment, and ground-water sample analyses at the Carus Chemical Company manufacturing facility and at several off-site locations. As part of the SSI, the IEPA conducted limited sampling of soil, sediment, and ground water to evaluate the chemical constituents at the site.

Four surface soil samples were collected at the site and one background surface soil sample was collected from Hegeler Park, located approximately 0.5 mi (0.8 km) northwest of the Carus Chemical Company manufacturing facility. The on-site surface samples collected during the IEPA investigation included: (i) two samples located east of the railroad embankment, where slag and other materials had been disposed; (ii) one sample located near the southeast corner of the manufacturing area; and (iii) one sample located adjacent to a former drum and filter bag storage area.

Eight surface sediment samples were also collected as part of the IEPA SSI. Five of the eight sediment samples were collected at the Carus Chemical Company manufacturing facility, including: (i) two samples from the south settling pond (hereinafter referred to as the holding pond); (ii) one sample from the emergency storage area; and (iii) two samples from the western bank of the Little Vermilion River. Three additional surface sediment samples were collected off-site from the west bank of the Little Vermilion River at locations upstream of the Carus Chemical Company manufacturing facility. These off-site sediment samples were collected at distances ranging between approximately 0.1 mi (0.2 km) and 0.2 mi (0.3 km) from the Carus Chemical Company property boundary.

IEPA collected samples from four ground-water monitoring wells as part of the SSI completed at the Carus Chemical Company manufacturing facility. Three samples were collected from on-site monitoring wells in existence at the time of the SSI maintained by Carus as part of its routine site monitoring program. The fourth ground-water sample, which was selected to represent background conditions, was obtained from the LaSalle Electrical Utilities NPL Site, located approximately 1.2 mi (1.9 km) north-northwest of the site.

Samples collected during the IEPA SSI were submitted for laboratory analysis of a suite of organic and inorganic chemical constituents in accordance with the USEPA Target Compound List (TCL). The TCL constituents included: (i) volatile organic compounds (VOCs); (ii) base/neutral and acid extractable organic compounds (BNAs); (iii) pesticides and polychlorinated biphenyls (PCBs); and (iv) inorganic compounds, including metals and inorganic anions (i.e., cyanide, sulfate, and sulfide). The results from the IEPA SSI are summarized and discussed in Section 5 of this report.

2.5.4 CERCLA PA/M&H Zinc Company

The IEPA conducted a separate PA at the M&H Zinc Company site in LaSalle, Illinois. The PA included a summary of the operational and regulatory history of the M&H site. In addition, as part of the PA, a site reconnaissance visit was conducted on 29 and 30 July and 18 August 1993. The PA report discusses the visual observations and information obtained from personal interviews during the site visit. No physical samples were collected.

2.5.5 CERCLA ISA/M&H Zinc Company

On 14 and 15 December 1993, the IEPA conducted a CERCLA ISA at the M&H Zinc Company site located in LaSalle, Illinois. The purpose of the ISA was to: (i) collect data in order to perform a preliminary HRS site score; (ii) establish priorities among sites most likely to qualify for the NPL; (iii) identify the most critical data requirements for any further investigation, if necessary; and (iv) determine whether the site should be forwarded within the Superfund process, either through the remedial or removal programs.

The ISA report provided a summary of the site history (i.e., ownership, operations, etc.), site inspection, and sampling results. As part of the ISA, the IEPA conducted limited on-site and off-site soil and sediment sampling to evaluate the presence of USEPA TCL constituents. The location of the on-site soil and sediment samples are shown on Figure 2-2.

Eight on-site soil samples and four on-site sediment samples were collected during the IEPA investigation. The location of these samples included: (i) three soil samples from the slag pile (i.e., X104, X105, and X106); (ii) two sediment samples from the west bank of the Little Vermilion River (i.e., X204 and X205); (iii) one sediment sample (plus a duplicate) next to the old sewer entrance into the Little Vermilion River (i.e., X202 and X203); (iv) one soil sample next to the old gas plant (i.e., X102); (v) two soil samples in the vicinity of the old south acid tank (i.e., X107 and X108); and (vi) one soil sample slightly north of the old pottery works (i.e., X103).

Fourteen off-site soil samples and one off-site sediment sample were also collected during the IEPA investigation. The sample locations were: (i) ten residential areas in the vicinity of the M&H site (within 1 mile); (ii) three from local schools within 1 mi (1.6 km) of the site; and (iii) one from the west bank and one from the east bank of the Little Vermilion River approximately 1.5 mi (2.4 km) north of the M&H site.

The results of the laboratory analysis indicated elevated concentrations of VOCs, semi-volatiles, pesticides, and inorganics in the soil samples. Laboratory results for the sediment samples indicated elevated concentrations of pesticides, one tentatively identified compound, and inorganics, including arsenic, cadmium, and lead.

2.5.6 Preliminary Site Investigation/Carus Chemical Company

In response to the IEPA's initiation of CERCLA administrative actions at the Carus Chemical site and, specifically, to the two CERCLA investigations conducted by the IEPA, Carus Chemical Company retained GeoSyntec to conduct a preliminary site investigation (PSI) at the Carus Chemical Company manufacturing facility. As part of the PSI, GeoSyntec completed a subsurface investigation in October 1992 (Figure 2-3). This investigation was conducted to assess chemical constituents contained within the soil, sediment, and ground water at the Carus Chemical Company manufacturing facility and suspected by the IEPA, and evaluate the potential for off-site impact.

Sixteen soil borings were advanced in order to: (i) visually examine the subsurface materials; (ii) collect samples for chemical analysis; and (iii) install additional ground-water monitoring wells. Soil and sediment samples were also collected from the Little Vermilion River and the holding pond and were submitted for chemical analysis. Ground-water samples were collected from the newly installed monitoring wells and also from three existing wells at the Carus Chemical Company manufacturing facility. To evaluate ground-water flow at the Carus Chemical Company manufacturing facility, GeoSyntec measured water levels in monitoring wells and also performed a single well aquifer test (slug test) in a monitoring well located within the slag-deposit area east of the railroad embankment.

Soil samples collected were analyzed using the Toxicity Characteristic Leaching Procedure (TCLP) for the eight Resource Conservation and Recovery Act (RCRA) metals, which included: arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. TCLP results for one of the samples collected from the slag deposit indicated a lead concentration of 5.21 mg/l, which was slightly in excess of the TCLP regulatory limit of 5 mg/l set forth in the Illinois Hazardous Waste Management Regulations (IHWMR). One of the samples collected from an area where sinter had been deposited indicated a cadmium concentration of 1.15 mg/l, which slightly exceeded the IHWMR TCLP limit of 1 mg/l for cadmium. No other constituents exceeded the IHWMR TCLP limits.

Two sediment samples were obtained from the Little Vermilion River. These samples were analyzed for nine inorganics including arsenic, barium, cadmium, chromium, lead, mercury, cyanide, selenium, and silver. All results were below regulatory limits per the IHWMR §721.24.

Ground-water samples were obtained from three existing monitoring wells and two monitoring wells installed by GeoSyntec as part of the PSI. These ground-water samples were analyzed for eight RCRA metals, including arsenic, barium, cadmium, chromium, lead, mercury, silver, and selenium. Of these constituents, slight exceedances were observed over the Class II Illinois Ground-Water Quality Standards provided in Section 620.420 (hereinafter referred to as the Class II ground-water quality standards) for barium and lead.

2.5.7 Phase I Site Investigation/Carus Chemical Company

The Phase I Investigation included the advancement of 18 soil borings, and the completion of three of the soil borings as ground-water monitoring wells. The investigation also included: (i) a water supply well exposure survey; (ii) evaluation of existing ground-water monitoring wells; (iii) slug testing; (iv) water level measurements; (v) soil sampling and analysis; (vi) surface-water sampling and analysis; (vii) ground-water sampling and analysis; and (viii) data assessment. A description of the investigation and the results of the analyses are presented in *"Phase I Site Investigation Completion Report - Carus Chemical Company Manufacturing Facility, LaSalle, Illinois"*, GeoSyntec, January 1994 (Phase I Report).

Based on the results of the site investigation, cross sections illustrating the geologic profile were developed. These cross sections reveal the presence of an erosional feature in the east-central part of the Phase I Area. Shallow perched ground water flows above the low permeability shale towards the erosional feature, then through the fill materials in the erosional feature to the face of the bluff. The cross section developed indicates that the mouth of the erosional feature was filled with sinter from the former M&H Zinc Company smelter. The remainder of the erosion feature was backfilled with soil. There is a shallow perched zone present which is recharged primarily by water from the infiltration of precipitation. The erosional feature is of limited extent. Results of this investigation indicated the existence of a shallow perched saturated zone that flows towards the bluff at the edge of the Phase I Area.

Elevated concentrations of cadmium, copper, lead, zinc, and sulfate based on total analyses were detected in samples of the slag materials. TCLP analyses of the soils and slag, however, indicate that none of the samples contained metal concentrations exceeding limits prescribed by IHWMR. The complete results and discussion of the analytical results of the Phase I Area are contained in the Phase I Report.

The following conclusions were developed based on the results of the site investigation in the Phase I Area:

- The Phase I Area is underlain at shallow depth primarily by Pennsylvanian-age shales and limestones, with minor amounts of coal. Up to 20 ft (6 m) of Pleistocene-age glacial deposits are present in the northeastern corner of the Phase I Area and up to 25 ft (7.5 m) of modern fill is present in the central and eastern part of the Phase I Area.

- Metals were found in some soil samples primarily confined to fill areas. The impacted soil samples contained elevated levels of cadmium, copper, lead, and/or zinc; however, the TCLP results indicate that none of the samples analyzed contained detectable quantities of metals in excess of the IHWMR limits (there is no IHWMR limit set for zinc).

- An upland flow system is present beneath the Phase I Area. The Pennsylvanian shales and limestones act together as the lower confining layer. Pleistocene fine till (dense, silty gravelly sand) also acts as a lateral confining unit on the eastern side of the area. Principal water-bearing units consist of the modern fill deposits and Pleistocene-age coarse till (well-graded sandy gravel).

- During the Phase I Site Investigation, the principal source of ground water in the Phase I Area was found to be fugitive discharge from the plant sewer. The sewer has since been repaired and carries used, non-contact cooling water from the plant to the discharge system at the Little Vermilion River. The cooling water is obtained from the LaSalle Municipal Water Works.

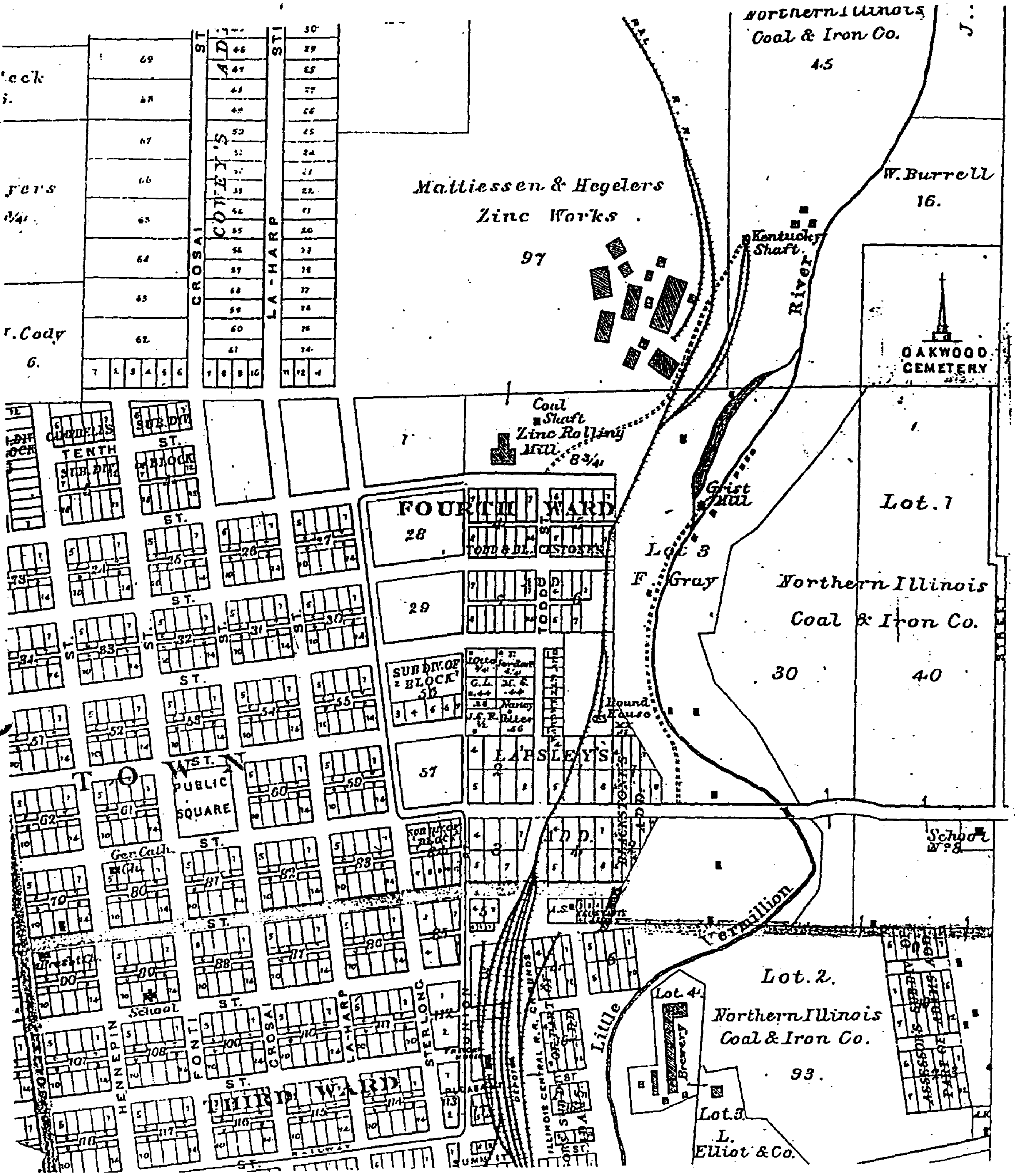
- The shallow perched ground water encountered in the fill materials in the erosion feature of the Phase I Area is a system separate and isolated from the ground water in the Phase II Area, as well as from the ground water at the former M&H Zinc Company properties.

- Sinter from the smelter at the former M&H Zinc Company was placed in an isolated area at the mouth of the erosion feature in the Phase I Area, and was later covered with soil.

- Relatively minor impacts to ground-water quality were detected in the shallow perched ground water in the fill materials downgradient from the sinter pile. However, the elevated lead concentrations appeared to be primarily associated with the turbidity of the water, and were not indicative of the mobility of lead in ground water.

- Elevated concentrations of benzene were detected in one monitoring well. These elevated concentrations appeared to result from surface-water runoff associated with spills from a tank located on the former M&H Zinc Company (now LaSalle Rolling Mills) property or overflow from the containment dike surrounding the tank during heavy rainfall.

- The impacts from the former M&H Zinc Company in the Phase I Area appear to be isolated and minor. If remediation is needed, corrective measures could easily be isolated from any other corrective measures implemented in the Carus Chemical Company Phase II Area or at the former M&H Zinc Company properties.



PLAT SURVEY OF LA SALLE, ILLINOIS–1876

GeoSyntec Consultants

FIGURE NO.	2–1
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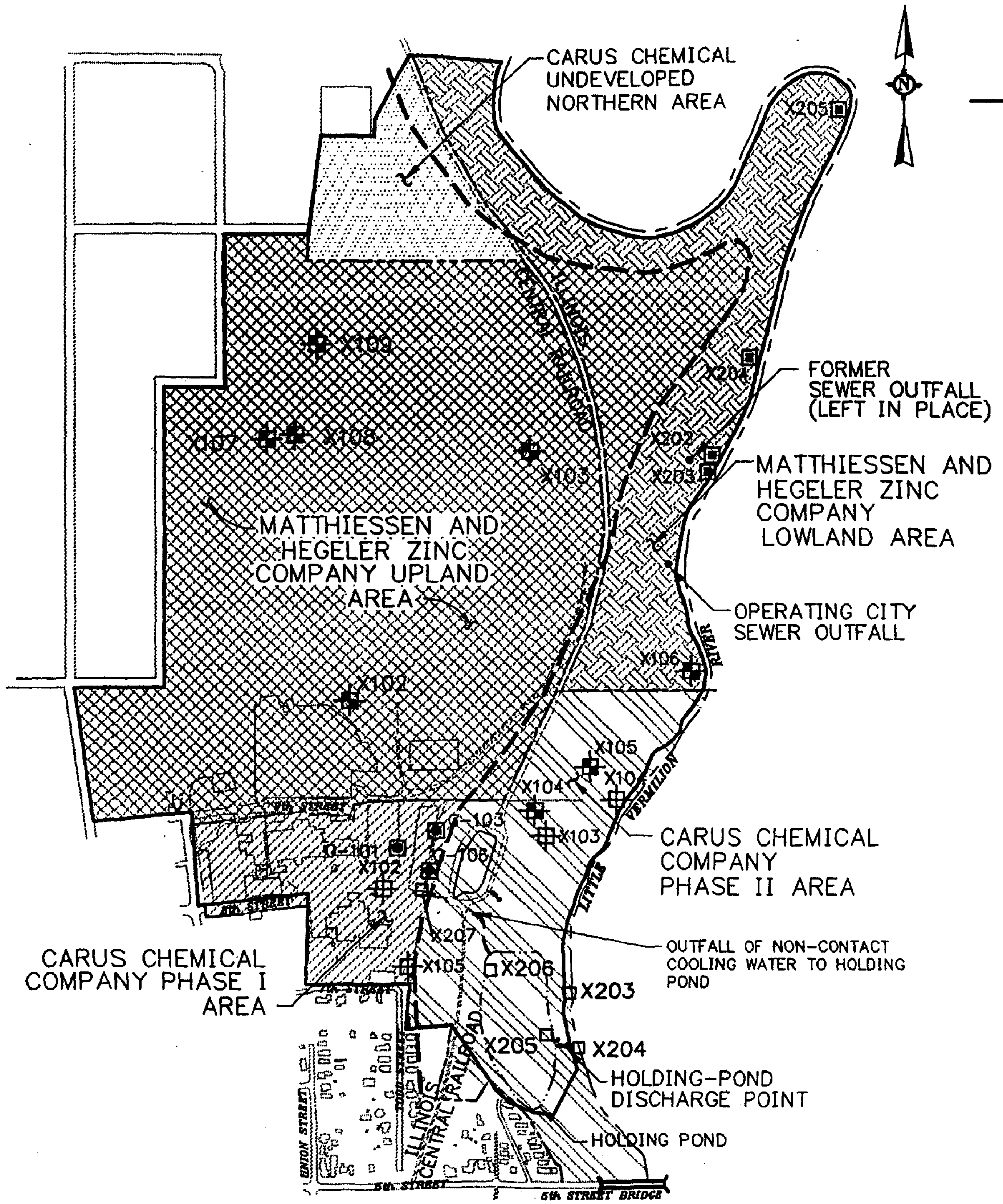

0 300 600

1 inch = 600 ft.

LEGEND

— — —	RIVER
-·-·-·-	HOLDING POND
— — — (bold)	TOP OF BLUFF
—·—·—	PROPERTY BOUNDARIES
□	CARUS CHEMICAL COMPANY CERCLA IEPA SSI SEDIMENT SAMPLE LOCATION
⊕	CARUS CHEMICAL COMPANY CERCLA IEPA SSI SOIL SAMPLE LOCATION
▣	CARUS CHEMICAL COMPANY CERCLA IEPA SSI GROUND-WATER SAMPLE LOCATION
▣	MATTHIESSEN AND HEGELER CERCLA INTEGRATED SITE ASSESSMENT SEDIMENT SAMPLE LOCATION
✚	MATTHIESSEN AND HEGELER CERCLA INTEGRATED SITE ASSESSMENT SOIL SAMPLE LOCATION
▨	CARUS CHEMICAL COMPANY PHASE I AREA
▧	CARUS CHEMICAL COMPANY PHASE II AREA
▩	FORMER MATTHIESSEN AND HEGELER ZINC COMPANY OPERATIONAL UPLAND AREA
▩	FORMER MATTHIESSEN AND HEGELER ZINC COMPANY OPERATIONAL LOWLAND AREA
░	CARUS CHEMICAL COMPANY UNDEVELOPED NORTHERN AREA

NOTES:

1. WELL AND FEATURE LOCATIONS TAKEN FROM DECEMBER 1994 CHAMLIN SURVEY.
2. LOCATION OF LITTLE VERMILION RIVER ESTIMATED BY SURVEYOR FROM OBSERVATIONS AND MAPS.
3. OUTLINES OF FEATURES IN PHASE II AREA ESTIMATED FROM AIR PHOTO AND MAP INTERPRETATION.
4. MATTHIESSEN AND HEGELER ZINC COMPANY CERCLIS SITE BOUNDARY ESTIMATED FROM AIR PHOTO AND MAP INTERPRETATION.

SAMPLING LOCATIONS FOR IEPA INVESTIGATIONS

GEOSYNTEC CONSULTANTS

FIGURE NO.	2-2
PROJECT NO.	FE2167
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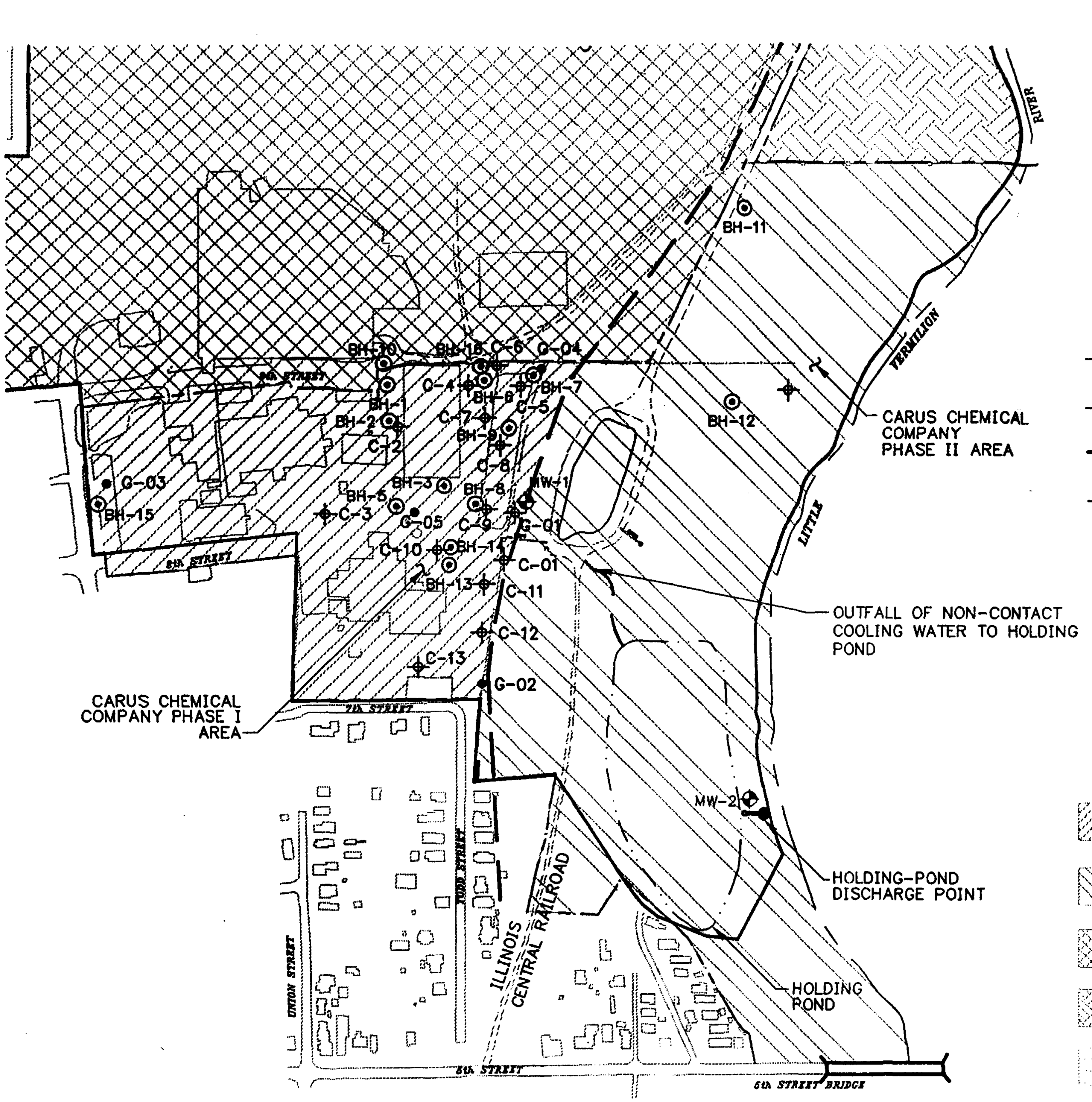

N

0 150 300

1 inch = 300 ft.

LEGEND

- RIVER
- HOLDING POND
- TOP OF BLUFF
- PROPERTY BOUNDARIES
- MW-1 MONITORING WELLS INSTALLED DURING PRELIMINARY ASSESSMENT (OCTOBER, 1992)
- BH-11 BORINGS INSTALLED DURING PRELIMINARY ASSESSMENT (OCTOBER, 1992)
- C-12 BORINGS INSTALLED DURING PHASE I INVESTIGATION (NOV. 1993)
- G-05 MONITORING WELLS INSTALLED DURING PHASE I INVESTIGATION (NOV. 1993)
- CARUS CHEMICAL COMPANY PHASE I AREA
- CARUS CHEMICAL COMPANY PHASE II AREA
- FORMER MATTHIESSEN AND HEGELER ZINC COMPANY OPERATIONAL UPLAND AREA
- FORMER MATTHIESSEN AND HEGELER ZINC COMPANY OPERATIONAL LOWLAND AREA
- CARUS CHEMICAL COMPANY UNDEVELOPED NORTHERN AREA

NOTES:

1. WELL AND FEATURE LOCATIONS TAKEN FROM DECEMBER 1994 CHAMLIN SURVEY.
2. LOCATION OF LITTLE VERMILION RIVER ESTIMATED BY SURVEYOR FROM OBSERVATIONS AND MAPS.
3. OUTLINES OF FEATURES IN PHASE II AREA ESTIMATED FROM AIR PHOTO AND MAP INTERPRETATION.
4. MATTHIESSEN AND HEGELER ZINC COMPANY CERCLIS SITE BOUNDARY ESTIMATED FROM AIR PHOTO AND MAP INTERPRETATION.

SAMPLING LOCATIONS FOR GEOSYNTEC PRELIMINARY SITE ASSESSMENT AND PHASE I INVESTIGATION

GEOSYNTEC CONSULTANTS

FIGURE NO.	2-3
PROJECT NO.	FE2167
DOCUMENT NO.	
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FIELD INVESTIGATION
AND RESULTS

3. FIELD INVESTIGATION AND RESULTS

3.1 Overview

As discussed in Section 4 of the Phase II Work Plan, the field investigation consisted of the following work elements, which are discussed in Sections 3.2 through 3.7 of this document:

- drilling and piezometer installation;
- hydrogeologic testing;
- river basin analysis;
- holding pond investigation;
- chemical analysis and sampling; and
- miscellaneous investigations.

The results of the field investigation, with the exception of the results of the chemical analyses (Section 5), are presented within Sections 3.2 through 3.7. The work elements were implemented in accordance with the Phase II Work Plan in order to evaluate the following issues:

- the mechanism of ground-water flow from the upland flow system in the Phase I Area into the lowland flow system in the Phase II Area;
- the extent to which water from the Little Vermilion River contacts the slag along the river bank;
- whether or not a significant thickness of alluvium is present beneath the slag and, if so, the transmissivity of the alluvium;

- the flow rate in the Little Vermilion River system at the property boundary;

- the concentrations of chemical constituents in ground water and surface water at the downstream property boundary;

- the concentrations of chemical constituents in ground water and surface water at the upstream and upgradient property boundary in order to establish background conditions;

- the extent of chemical constituents in the ground water in the Phase II Area; and

- the potential sources of chemical constituents, including:

    - the slag deposits,
    - holding pond sediments,
    - off-site sources, and
    - natural rocks and soils.

A copy of the field notes documenting the field work performed for the investigation is provided as Appendix A. Photographic documentation of the field investigation is provided as Appendix B.

3.2 Drilling and Piezometer Installation

3.2.1 Drilling and Subsurface Soil Sampling

Eighteen soil borings were drilled as part of the Phase II Investigation using hollow-stem augers. The locations of these borings are shown on Drawing 1. Ten of the borings were completed as piezometers, and eight were backfilled using bentonite and abandoned in accordance with IEPA protocol. The depths of the borings are shown on Table 3.1. All borings were logged by a geologist. Boring logs are provided in Appendix C.

Subsurface soil samples were collected at selected intervals for: (i) visual description and classification; (ii) laboratory chemical analysis; and (iii) laboratory permeability analysis. The specific intervals sampled are shown on the boring logs (Appendix C); the samples submitted for chemical analysis are listed on Table 3.1. Subsurface soil samples were collected using the split-spoon method in accordance with American Society for Testing and Materials (ASTM) Method D 1586.

As discussed in the Phase II Work Plan, and in accordance with the Field Sampling Plan, all downhole drilling and sampling equipment was decontaminated prior to use in each test boring. In addition, all devices that were in contact with samples collected for laboratory analysis were decontaminated prior to use.

3.2.2 Piezometer Installation and Development

Ten piezometers were installed during the Phase II Investigation in order to evaluate ground-water quality and hydrogeologic conditions. The locations of these piezometers are shown on Drawing 1. Table 3.1 provides the screened interval depth and depth to water. Survey results of piezometers and existing site monitoring wells are provided in Table 3.2.

Piezometers were constructed using nominal 2-in. (50-mm) diameter polyvinyl chloride (PVC) well screen and pipe. PVC was selected because it provides the best combination of serviceability and chemical resistance to metals, which are the principal constituents of concern at the site. Stainless steel was not chosen because metals are the constituents of concern at this site and because of the potential for metals to potentially leach from the casing into the ground water. The piezometers were constructed using varying lengths of factory-slotted PVC screen with 0.010-in. (25-μm) wide apertures. The annulus between the borehole wall and the screen was filled with uniform, quartz filter sand (Global Sand Co. No. 7). The annular seal above the filter sand was constructed using granular and chipped bentonite which was hydrated in place. This type of seal was used in lieu of a grout slurry since during the Phase I Investigation, GeoSyntec observed that the slag did not retain grout slurries and thus failed to provide an adequate seal of the annular space. Surface completion of the piezometers consisted of setting a section of steel casing with a locking cap in concrete to protect the well head.

The piezometers were developed following construction; existing monitoring well MW-2 was redeveloped. Piezometers P-1, P-17, P-18, and P-19, and monitoring well MW-2 were developed using a Grundfos Rediflo submersible pump. Piezometers P-6, P-7, P-9, P-15, and P-15A were developed manually with a bailer. Piezometer P-20 was not developed due to insufficient water yield. All piezometers were repeatedly surged using a bailer throughout the development process. During well development, water quality parameters (e.g., pH, temperature, specific conductance, and visual turbidity) were monitored. Development continued until the discharge water was visually clear.

3.3 Hydrogeologic Testing

Water-level measurements and hydrogeologic testing were performed to help determine the rate and direction of ground-water flow. Two types of hydrogeologic tests were performed: (i) slug tests; and (ii) pump tests.

3.3.1 Water-Level Measurements

Water levels were measured in all of the piezometers and monitoring wells on site as part of the Phase II Investigation (Table 3.3). Water-level measurements were obtained using an electronic water level probe and are considered accurate to ± 0.01 ft. (± 1.5 mm).

3.3.2 Slug Tests and Pump Tests

Nine slug tests and four pump tests were performed during the Phase II Investigation. The purpose of these tests was to evaluate the hydraulic conductivity and flow characteristics in different areas of the site. The slug test and pump test results are presented in Table 3.4. The slug and pump test data are suitable for qualitative and approximate quantitative analysis. Original data, drawdown curves, and calculations are presented in Appendix D.

Slug test data were analyzed using the Bouwer and Rice [1976] model for partially penetrating wells in unconfined aquifers. The double straight-line effect of Bouwer [1989] was taken into consideration. Slug test data analyses were performed using AQUIX-4S, a computer software package from Envirotools, Ltd. [1992].

Pump test data were analyzed using a variety of models and assumptions, as described in Appendix D.

3.4 River Basin Analysis

3.4.1 Introduction

The River Basin Analysis was conducted to evaluate the possibility that ground-water flow in the slag deposits is part of the same system as the water in the Little Vermilion River. Field observations were made, as discussed in Section 3.7, and the volume of flow in the Little Vermilion River was estimated, as discussed in Section 3.4.2. In addition, river water and sediment samples obtained from three locations were analyzed, as discussed in Section 3.6.7.

3.4.2 Profiling and Flow Measurement

The volume of flow in the Little Vermilion River was determined on 7 October 1994 at the four locations as indicated on Drawing 1. Flow volume for the river was calculated from the flow velocity and the cross-sectional area of the stream at each profile location. Measurements of depth and velocity were made at approximately 5 ft (1.5 m) intervals across the width of the river. Velocities were measured using an electronic flow meter at one third and two thirds of the depth of water. Profiling and flow calculation data are provided in Appendix E.

The northernmost measurement was taken where the northern property line of the Phase II Area crosses the river. The mid-northern measurement was taken near boring P-22, in the area where flow in the river is most constricted by the slag deposits, and therefore is most rapid. The mid-southern measurement was taken south of the rapidly flowing section of the river, near piezometer P-17 (i.e., near the northern edge of the holding pond). The southernmost measurement was taken downstream of the holding pond outfall. The results of the stream flow measurements for each location are presented in Table 3.5.

At the time of measurement (i.e., 7 October 1994), the volume of flow in the Little Vermilion River ranged from approximately 6 to 14 ft^3/s. During the course of the subsequent field work, abundant rainfall caused the river to rise approximately 2 ft (0.6 m) from the level measured on 7 October 1994. GeoSyntec attempted to measure flow in the river while it was at this higher stage, but was unable to do so because the strength of the current and depth of water made the work too dangerous.

3.5 Holding Pond Investigation

3.5.1 Introduction

The holding pond at the southern end of the Phase II Area was evaluated as a possible source of the elevated level of manganese detected in monitoring well MW-2 during GeoSyntec's PSI which was completed in October 1992. The holding pond investigation was also prompted by the IEPA SSI conducted in November 1991 where metals and polynuclear aromatic hydrocarbons (PAHs) were found in the holding pond sediments. The holding pond investigation consisted of the following work elements: (i) evaluate the extent and thickness of the pond sediment; (ii) evaluate the permeability of the pond sediments; and (iii) chemically characterize the pond sediment. Pond sediment sampling is discussed in Section 3.6.8.

3.5.2 Extent and Thickness of Pond Sediment

In order to determine the thickness of the pond sediment, two activities were performed: (i) historical topographic maps were reviewed to determine the lower extent of the pond sediment through inference (i.e., the topographic elevations were evaluated prior to construction of the holding pond); and (ii) the upper extent of the pond sediment was measured in the field, as described below.

The water depth in the holding pond was measured along four profiles on 3 November 1994. In general, the northern third of the pond is less than 2 ft (0.6 m) deep, the middle third is approximately 3 ft (1 m) deep, and the southern third is approximately 5 ft (1.5 m) deep. Overall, the substrate in the holding pond was found to be very soft, as defined by ASTM Method D 2488.

The depth (below water) to firm substrate was also measured along the central axis of the pond. Firm to stiff substrate was encountered at approximately 3.5 ft (1.1 m) in the northern third of the pond and at a depth of 8.3 ft (2.5 m) in the middle third of the pond. In the southern third of the pond, firmer substrate was not encountered above 11 ft (3.3 m), which was the length of the probe rods. The thickness of firm substrate is estimated to range between approximately 20 and 25 ft (6.1 and 7.6 m).

3.5.3 Permeability of the Pond Sediments

The purpose in determining the permeability of the pond sediments was to evaluate potential leakage from the holding pond. Accessibility and safety reasons precluded obtaining Shelby tubes from the pond sediments for laboratory analysis to determine hydraulic conductivity. Therefore, in order to accomplish the objective (i.e., to evaluate potential leakage from the holding pond), the following tasks were performed: (i) flow into and out of the holding pond were measured at the intake and outfall points; (ii) a field reconnaissance was conducted to locate springs or seeps that could effect water balance; (iii) a sensitivity analysis was conducted by evaluating the effect of a significant rainfall event on water balance; (iv) observations were made during borehole advancement through the berm located adjacent to the holding pond; and (v) the upper range of potential leakage through the pond was estimated using the Darcy equation.

The holding pond was designed to receive water from the plant sewer and discharge this water under an NPDES permit through the outfall pipe into the Little Vermilion River. The intake points consist of the facility sewer pipe (1.55-ft (0.47-m) diameter) and the boiler blowdown pipe (3-in. (76-mm) diameter). The outfall point (i.e., discharge pipe) is a 2-ft (0.6-m) diameter concrete pipe with a 19 degree slope. To evaluate the potential for leakage from the holding pond, flow into and out of the pond through the intake and outfall points was measured on several occasions. The results of the flow measurements are presented in Table 3.6; the data and calculations are presented in Appendix F. The evaluation demonstrated that inflow through the facility sewer and the boiler blowdown pipes was approximately equal (within 1 ft^3/s (0.028 m^3/s) accuracy) to the outflow through the discharge pipe.

To evaluate the relative contribution of non-plant water sources entering the pond, additional sources of water, including potential seeps and springs, direct precipitation, and overland flow from the holding pond catchment area were evaluated. No seeps or springs that would significantly effect the water balance were observed. The holding pond catchment area consists of about 2 acres (0.8 hectares) of land located between the Phase I Area and the holding pond. The measured relationship between inflow and outflow measurements and precipitation events is indicated on Table 3.6. The potential contribution of precipitation was evaluated by using 3 in. (75 mm) of rain in one day over 5 acres (2 hectares), which includes the pond plus the catchment area. This rainfall event would contribute 0.6 ft^3/s (0.018 m^3/s) of water to the holding pond, assuming instantaneous runoff from the catchment area.

Soil/slag conditions were noted during the field investigation as borings P-15 and P-17 were advanced through the berm which was constructed primarily of bricks and slag between the holding pond and the Little Vermilion River. In boring P-15, moist conditions were encountered at 13 ft (4 m) and saturated conditions at 23 ft (7 m) below the ground surface, as indicated on the boring logs (Appendix C). In boring P-17, saturated conditions were encountered at 33 ft (10 m) below ground surface. When compared to the surface-water elevation of the Little Vermilion River, water level measurements taken from monitoring well MW-2 and piezometers P-15, P-15A, and P-17 indicate that some mounding may be occurring within the berm as a result of leakage from the holding pond.

The upper range of potential leakage through the pond was estimated using the Darcy equation and the following assumptions: (i) the surface area of the pond is 3 acres (1.2 hectares); (ii) the average pond sediment thickness is 30 ft (9 m); (iii) the hydraulic conductivity of the pond sediment is 1 x 10^{-5} cm/s; and (iv) the hydraulic head difference between the surface of the holding pond and the Little Vermilion River is 30 ft (9 m). As presented in Appendix F, the upper range for flow from the holding pond is estimated to be on the order of 0.045 ft^3/s (0.001 m^3/s), which is less than the accuracy of the inflow and outflow conditions discussed above.

3.6 Sampling and Chemical Analysis

3.6.1 Introduction

The Phase II Investigation included sampling and chemical analysis of: (i) soil/slag samples obtained from the borings; (ii) ground-water samples obtained from the monitoring wells; (iii) water and sediment samples obtained from the Little Vermilion River; and (iv) sediments obtained from the holding pond. The sampling locations are shown on Drawing 1. Chemical analyses of all samples collected during the Phase II Area investigation were performed by ARDL, Inc. (ARDL) of Mount Vernon, Illinois. ARDL is currently, and has been for the past seven years, a participant in the Contract Laboratory Program (CLP) of the IEPA. The data reports from ARDL are provided in Appendix G.

The remainder of this section addresses three issues regarding the analytical program for the Phase II Investigation: (i) analytical suites; (ii) data quality objectives; and (iii) field quality control. In addition, the samples obtained for analysis are described.

3.6.2 Analytical Suites

The analyses performed for the Phase II Investigation were organized into three analytical suites: (i) the metals focused suite; (ii) the petroleum focused suite; and (iii) the PAH suite, a sub-group of the petroleum focused suite. The specific components of each suite are listed in Table 3.7.

The metals focused suite consisted of nine metals and five anions. These metals and the anion cyanide were selected because they had been recognized in previous investigations as potential constituents of concern. Several of these metals and cyanide are also defined as hazardous substances under CERCLA. The other anions were selected for the insight that they might provide regarding the origin and chemical state of the metals. The metals focused suite was performed on all samples collected for the Phase II Investigation. In general, the metals focused suite was designed to address potential concerns relating to past industrial operations in the area.

The petroleum focused suite consisted of those analyses required by the IEPA for investigations of leaking underground storage tanks. The petroleum focused suite was performed on samples collected near the northeast corner of the Phase I Area, where petroleum fuel components had been found previously [Phase I and PSI reports].

The PAH suite consisted of polynuclear aromatic hydrocarbons from the petroleum focused suite. The PAH suite was performed only on sediment samples obtained from the holding pond because PAHs had been found during the SSI conducted by the IEPA.

3.6.3 Data Quality Objectives

Data Quality Objectives (DQOs) have been established by the IEPA in order to categorize levels of confidence in analytical programs [IEPA, 1994]. The Phase II Investigation analyses were performed using the procedures of DQO Level IV, which "provides the highest level of data quality and is used for the purposes of risk assessment and evaluation of remedial alternatives [IEPA, 1994, p. 3 of 25]."

The IEPA has also established three Categories of Decision regarding analytical results [IEPA, 1994]. These Categories are not protocols to be followed, like the DQOs, but rather quality control goals that may or may not be attainable, depending upon the nature of the sample submitted. Of the three categories, Category B is considered appropriate for site characterization work and Category C is considered appropriate for "demonstration of attainment of site cleanup objectives and specific project objectives [IEPA, 1994, p. 1 of 25]." Where possible, ARDL attempted to meet the Category C goals on all analyses.

3.6.4 Field Quality Control Samples

Field quality control samples were collected in order to assess the potential for sample corruption during collection and handling and in order to evaluate the repeatability of the findings. Two types of quality control samples were collected and analyzed: (i) equipment blanks; and (ii) duplicate samples.

Equipment blanks consisted of samples of the water used for decontamination after passing that water through decontamination tubing, filter equipment, and other devices used in the sample collection process.

Two duplicate ground-water samples, one duplicate soil sample, one duplicate river water sample, and one duplicate holding pond sediment sample were obtained for quality control purposes. The results of the analysis are presented in Section 5 of this report.

3.6.5 Soil/Slag Samples

As shown on Table 3.8, 18 soil/slag samples were collected from nine borings during the Phase II Investigation. The samples were obtained from the stainless steel split spoon sampler (ASTM Method D 1586). The samples were analyzed for the metals focused suite using total and TCLP analyses.

3.6.6 Ground-Water Samples

Fourteen ground-water samples (including two quality assurance samples) were collected during the Phase II Investigation. The 14 samples were collected from nine of the newly installed piezometers and three of the existing monitoring wells. The quality assurance samples included a duplicate from monitoring well MW-1, and a filtered sample for total metals analysis from piezometer P-18. The ground-water sampling program is summarized in Table 3.9. The ground-water sampling procedures are detailed in Appendix H.

All samples were analyzed for the metals focused suite with the exception of piezometer P-18 which was analyzed for both filtered and unfiltered metals. Samples from piezometer P-6 and monitoring well G-04 were analyzed for both the metals focused and the petroleum focused suites. During purging prior to sampling, general purge-water quality parameters (e.g., temperature, pH, conductivity, redox potential, and visual turbidity) were monitored. The results of this monitoring are presented in Table 3.10.

Samples for metals analysis were collected without filtering, except in cases where turbidity was estimated to exceed 5 nephalometric turbidity units (NTUs). Where filtering was found to be necessary, a 5 μm opening cellulose filter was used. In order to minimize the need for filtering, low flow purging sampling techniques were utilized where possible. These techniques are described in detail in Appendix H. In order to provide a basis for evaluating the effect of filtering, both filtered and unfiltered samples were collected from piezometer P-18. Comparison of these data suggest that samples collected using techniques designed to minimize turbidity are comparable to samples filtered using a 5 μm filter.

3.6.7 River Water and Sediment Sampling

Water and sediment samples were collected from the Little Vermilion River on 8 and 11 November 1994, at the three locations shown on Figure 3-1. Water samples were collected by directly filling the sample bottles from the river. Sediment samples were collected by scooping sediment from areas of low flow velocities where sand and silt size sediment was available. The water samples were analyzed for the metals focused and PAH suites.

The northernmost location is upstream and away from all industrial activities associated with the manufacturing of zinc or manganese products. The middle location was collected where the northern property line of Phase II Area crosses the river. The southernmost location was collected beneath the Fifth Street Bridge, which is downstream of all Carus Chemical Company manufacturing facility operations. These sample locations were chosen in order to provide a means of comparing the change in metal concentrations in river water and underlying sediment as the river approaches and flows past the Carus Chemical Company property. The river water sampling program is outlined in Table 3.11.

3.6.8 Holding Pond Sediment Samples

Three composite holding pond sediment samples were collected from locations shown on Figure 3-2. The samples were collected with a stainless steel sludge auger and composited in a mixing bowl. These samples were analyzed for the metals focused suite and for the PAH group from the petroleum focused suite. Sediment sample descriptions and the analyses performed are provided on Table 3.12.

3.7 Miscellaneous Investigations

3.7.1 Phase II Area Field Observations

Specific geologic observations were made during the Phase II Area Investigation. Most of these observations were made as part of deliberate reconnaissance and mapping efforts by Mr. Raymer and Dr. Pelte, the investigating geologists. These efforts are summarized below.

- The entire length of the Little Vermilion River, from the northern to the southern end of the Phase II Area was examined. The location and types of alluvium, the nature of floodplain deposits, and the nature of flow in the river were observed.

- The slag pile was examined in detail, especially in the vicinity of P-22, where erosion by the Little Vermilion River has exposed a section of the slag pile. Specific emphasis was given to both the anticipated hydrogeological character of the deposits and the presence of material other than slag in the pile.

- The hillsides between the Phase I Area and the ICRR grade and between the ICRR grade and the holding pond, were examined for seeps and exposures of bedrock and fill material.

- The eastern side of the holding pond berm was examined for seeps or evidence of leakage from the holding pond.

3.7.2 Surveying

Points where samples or other data were collected were surveyed by Chamlin and Associates (Chamlin), of Peru, Illinois. Drawing 1 includes sampling locations surveyed for the Phase II Investigation. Sampling locations, elevations, and other features not shown on Drawing 1 but which are shown on other drawings have been visually located or were transposed from earlier drawings provided by Carus Chemical Company.

Table 3.1. Summary Information for Borings and Piezometers
Phase II Investigation, Carus Chemical Company

Boring/ Piezometer(1)		Total(2) Depth	Screened Interval(2)		Depth to Water(2)
			Top	Bottom	
P-1	Piezometer	90.0	78.0	88.0	81.9
P-2	Boring	72.0	-	-	dry
P-3	Boring	15.5	-	-	dry
P-4	Boring	12.1	-	-	dry
P-6	Piezometer	25.5	9.0	24.0	18.0
P-7	Piezometer	22.7	10.0	20.0	13.2
P-9	Piezometer	12.0	5.0	10.0	6.2
P-10	Boring	7.5	-	-	dry
P-11	Boring	13.0	-	-	dry
P-12	Boring	5.0	-	-	dry
P-15	Piezometer	45.5	35.0	40.0	23.9
P-15A	Piezometer	25.0	20.0	25.0	20.9
P-17	Piezometer	55.0	38.0	48.0	29.5
P-18	Piezometer	62.0	50.0	60.0	45.4
P-19	Piezometer	61.0	43.0	53.0	50.1
P-20	Piezometer	21.5	11.0	21.0	dry
P-21	Boring	77.0	-	-	dry
P-22	Boring	121.0	-	-	90.0

Notes: (1) All borings from the Phase II investigation have the prefix "P". Piezometers have the same designation as the borings in which they were installed. "Piezometer" in the column to the right of the Piezometer name indicates that a piezometer was installed. "Boring" indicates that the borehole was plugged and abandoned.
(2) All depths in feet below ground surface.

Table 3.2. Piezometer/Well Completion Elevations of Phase I and Phase II Area Piezometers and Monitoring Wells

Well	TOC Elevation (ft msl)	TOC Height Above Ground (ft)	Ground Elev. (ft msl)
G-101	575.98	2.27	573.71
G-103	574.57	1.87	572.70
G-106	573.23	1.71	571.52
G-02	568.39	2.70	565.69
G-04	575.30	2.67	572.63
G-05	577.47	2.58	574.89
MW-1	572.27	2.49	569.78
MW-2	489.08	0.00	489.08
P-1	548.81	1.86	546.95
P-6	573.95	2.64	571.31
P-7	545.21	2.66	542.55
P-9	534.53	2.67	531.86
P-15	491.78	2.57	489.21
P-15A	492.02	2.80	489.22
P-17	490.40	2.69	487.71
P-18	508.49	2.64	505.85
P-19	514.54	2.64	511.90
P-20	545.97	2.78	543.19

Notes:

TOC: top of well casing (i.e. well pipe).
BOW: depth to bottom of well from TOC.

Table 3.3. Water Levels Measured During the Phase II Investigation

Well/ Piezometer	3 Oct 94		10 Oct 94		4 Nov 94		12 Nov 94	
	DTW	WLE	DTW	WLE	DTW	WLE	DTW	WLE
G-101	13.95	562.03	14.03	561.95	14.02	561.96	13.20	562.58
G-103	15.41	559.16	15.04	559.53	15.20	559.37	14.59	559.74
G-106	25.18	548.05	25.12	548.11	25.00	548.23	24.75	548.28
G-02	10.67	557.72	10.77	557.62	10.13	558.26	9.58	558.81
G-04	16.18	559.15	16.03	559.27	15.72	559.58	15.13	560.17
G-05	15.17	562.30	15.32	562.15	15.39	562.08	15.06	562.41
MW-1	16.33	555.94	16.40	555.87	16.49	555.78	16.24	556.03
MW-2	33.16	455.92	32.95	456.13	32.41	456.67	31.45	457.63
P-1	-	-	84.79	466.00	84.68	466.20	83.92	466.87
P-6	-	-	-	-	20.44	553.51	20.33	553.62
P-7	16.87	528.34	15.90	529.31	15.47	529.74	15.29	529.92
P-9	8.91	525.62	8.89	525.64	8.84	525.69	8.81	525.72
P-15	24.88	466.92	26.43	465.37	25.71	466.09	24.74	467.06
P-15A	23.65	468.37	23.70	468.32	24.03	467.99	23.88	468.14
P-17	32.31	458.09	32.18	458.22	31.93	458.47	31.06	459.34
P-18	47.95	460.54	42.99	460.50	47.58	460.91	46.68	461.81
P-19	52.71	461.93	52.78	461.76	52.45	462.09	51.42	463.12

Notes: (1) DTW: depth to water measured in ft below TOC (top of well casing) as reported in Table 3.2.
(2) WLE: water level elevation in ft mean sea level (msl), calculated by subtracting DTW from TOC elevation.

Table 3.4. Hydraulic Conductivity Data

Well / Piezometer	Hydraulic Conductivity		Remarks
	(cm/sec)	(ft/min)	
P-6	1.6×10^{-4}	3.2×10^{-4}	Slug Test
P-7	9.5×10^{-5}	1.9×10^{-4}	Slug Test
P-9	5.0×10^{-4}	1.0×10^{-3}	Slug Test
P-15	4.6×10^{-6}	9.1×10^{-5}	Slug Test
P-17	$\sim 5 \times 10^{-3}$	$\sim 1 \times 10^{-2}$	Pump Test
P-18	2.2×10^{-2}	4.3×10^{-2}	Slug test
P-18	$\sim 4 \times 10^{-2}$	8×10^{-2}	Pump Test
MW-1	$\sim 2 \times 10^{-1}$	$\sim 4 \times 10^{-1}$	Pump Test
MW-1	$*5.7 \times 10^{-2}$	$*1.1 \times 10^{-1}$	Slug Test
MW-2	$\sim 7 \times 10^{-3}$	1×10^{-2}	Pump Test
G-02	4.0×10^{-6}	7.9×10^{-6}	Slug Test
G-04	2.7×10^{-3}	5.4×10^{-3}	Slug Test
G-05	2.0×10^{-3}	4.0×10^{-3}	Slug Test

Notes:

1. Slug tests and pump tests were performed during the Phase II Investigation following ground-water sampling. Slug test data were analyzed using the Bouwer and Rice model. Pump test data were analyzed using the Theis equation.

* Indicates a second set of data for the same well.

Table 3.5. Results of Stream Flow Measurements (7 October 1994)

Point[1]	Location	River Elevation (ft)	Flow (ft^3/s)
1	80 ft south of outfall (P-15)	457	14.0
2	200 ft north of outfall (P-17)	457	6.1
3	550 ft north of outfall (P-18)	459	8.5
4	100 ft south of section line (P-1)	465	6.6

Note:

[1] Refers to location shown on Drawing 1.

Table 3.6. Results of Holding Pond Measurements

Date	Inflow (ft^3/sec)	Outflow (ft^3/sec)	Difference (ft^3/sec)	Recent Precipitation
5 Oct.94	2.5	3.1	-0.6	No
7 Oct. 94	2.7	2.7	0	No
31 Oct. 94	4	7	-3	During Rain

Notes:

1. Inflow measurements include sum of plant sewer, boiler blowdown pipe, and storm sewer from the Lined Emergency Storage Basin. The storm sewer from the Lined Emergency Storage Basin only flows during larger rainfall events.

2. Differences less than 1 ft^3/sec are less than the precision of measurement, and therefore are considered insignificant.

Table 3.7. Analytical Suites

METALS FOCUSED SUITE		
METALS	ANIONS	FIELD PARAMETERS
Barium Cadmium Chromium Iron Lead Manganese Mercury Nickel Zinc	Sulfate Sulfide Carbonate Bicarbonate Cyanide	Temperature Conductivity Redox Potential pH

PETROLEUM FOCUSED SITE		
BTEX GROUP	PAH SUITE	UST METALS GROUP
Benzene Toluene Ethyl Benzene Xylenes (Total)	Naphthalene Acenaphthalene Acenapthene Fluorene Phenanthrene Anthracene Fluoranthene Pyrene Benzo(a)anthracene Chrysene Benzo(b)fluoranthene Benzo(k)fluoranthene Benzo(a)pyrene Dibenzo(a,h)anthracene Benzo(g,h,i)perylene Indeno(1,2,3-cd)pyrene	Arsenic Barium Cadmium Chromium Lead Mercury Selenium

Table 3.8. Soil/Slag Sampling Program

Boring/ Piezometer(1)		Soil Samples for Chemical Analysis		
		Approximate Depth(2)	Sample	Date
P-1	Piezometer	21	P121	3 Oct 94
		80	P180	3 Oct 94
P-2	Boring	19	P219	4 Oct 94
		42	P242	4 Oct 94
		42	P242DP	4 Oct 94
P-15A	Piezometer	20	P15A20	29 Sep 94
P-17	Piezometer	10	P1710	29 Sep 94
		42	P1742	29 Sep 94
P-18	Piezometer	39	P1839	28 Sep 94
P-19	Piezometer	20	P1920	29 Sep 94
		42	P1942	29 Sep 94
P-21	Boring	21	P2121	30 Sep 94
		41	P2141	30 Sep 94
		80	P2180	30 Sep 94
		2.5	P212.5	3 Oct 94
P-22	Boring	41	P2241	4 Oct 94
		106	P22106	5 Oct 94

Table 3.9. Ground-Water Sampling Program

Point	Date	Method	Filtered	Analytical Suites
P-1	8 Nov 94	Submersible Pump	No	Metals Focused
P-6	8 Nov 94	Peristaltic Pump (Bailer for BTEX)	Yes	Metals Focused Petroleum Focused
P-7	7 Nov 94	Peristaltic Pump	No	Metals Focused
P-9	7 Nov 94	Peristaltic Pump	No	Metals Focused
P-15	9 Nov 94	Bailer	Yes	Metals Focused
P-15A	8 Nov 94	Bailer	Yes	Metals Focused
P-17	9 Nov 94	Submersible Pump	No	Metals Focused
P-18	10 Nov 94	Submersible Pump	No	Metals Focused
P-18_{filt}	10 Nov 94	Submersible Pump	Yes	Metals Only
P-19	10 Nov 94	Bailer	Yes	Metals Focused
MW-1	5 Nov 94	Peristaltic Pump	No	Metals Focused
MW-1_{dup}	5 Nov 94	Peristaltic Pump	No	Metals Focused
MW-2	9 Nov 94	Submersible Pump	No	Metals Focused
G-04	8 Nov 94	Peristaltic Pump	No	Metals Focused Petroleum Focused

filt = filtered
dup = duplicate sample

Table 3.10. Water-Quality Properties Measured in the Field

Point	Date	Temperature (°C)	pH	Conductivity μmhos/cm	Redox (mv)
P-1	10 Nov. 94	14.9	4.51	5300	+217
P-6	8 Nov. 94	13.6	6.58	240-300	+59
P-7	7 Nov. 94	19.0	6.45	290-360	-110
P-9	7 Nov. 94	14.7	6.44	420-440	+94
P-15	9 Nov. 94	17.5	6.70	3200	-
P-15A	8 Nov. 94	18.6	6.72	900-1100	-2
P-17	9 Nov. 94	19.1	6.72	3010	-90
P-18	10 Nov. 94	19.0	6.15	4230	-49
P-19	10 Nov. 94	15.3	7.30	2990	+35
G-04	8 Nov.94	13.7	6.65	1000-2000	-153
MW-1	5 Nov. 94	14.9	6.32	238-271	-66
MW-2	9 Nov. 94	19.4	6.91	3040	-108
Sect. Line Riv.	11 Nov. 94	7.8	7.58	750	+54
P-18 Riv.	10 Nov. 94	12.0	7.28	1208	+25
Outfall Riv.	10 Nov. 94	9.5	7.90	369	-10
5th St Riv.	10 Nov. 94	9.8	7.89	770	-78
Plant Sewer	10 Nov. 94	22.8	8.07	710	+92
Boil. Bl. Pipe	10 Nov. 94	29.6	11.76	2580	-233
Pond	10 Nov. 94	17.2	7.59	1260	-78

1. Water properties measured using a YSI 3500 Water Quality Meter.
2. Ground-water samples measured using a flow-through cell to prevent interaction of water and air. Ground-water samples taken from end of purging cycle during well sampling.

Table 3.11. River Water and Sediment Sampling Program

Point	Date	Filtered	Analytical Suite
LVR: Quarry Bridge	8 Nov 94	No	Metals Focused
LVR: Section Line	11 Nov 94	No	Metals Focused
LVR: 5th St. Bridge	8 Nov 94	No	Metals Focused

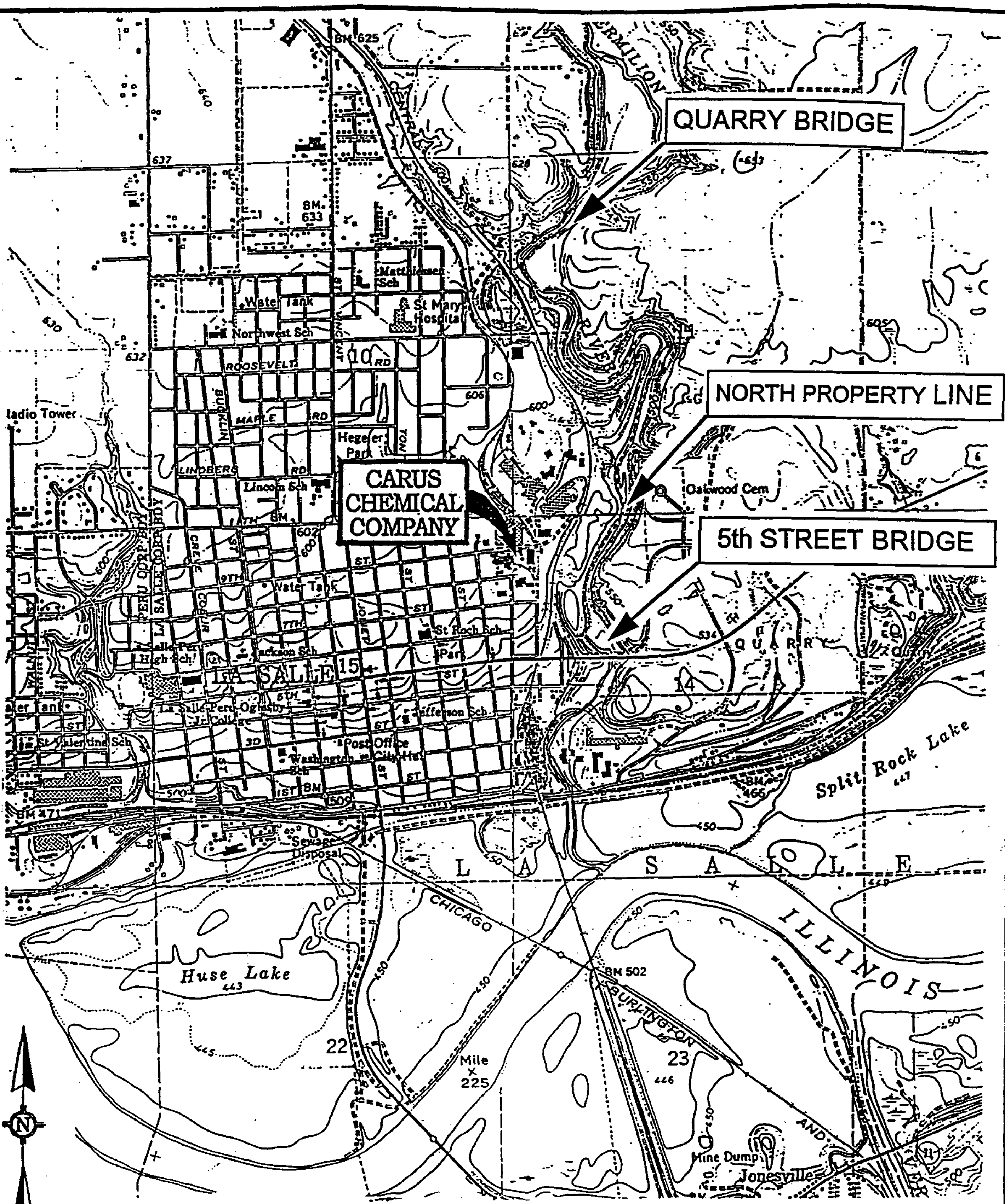
Point	Date	Sample Description	Analytical Suite
LVR: Quarry Bridge	8 Nov 94	Fine sandy silt	Metals Focused
LVR: Section Line	11 Nov 94	Sandy gravel with limestone, trace of slate and slag.	Metals Focused
LVR: 5th St. Bridge	8 Nov 94	Sand with fine gravel of limestone, trace of slag and slate	Metals Focused

Note:

LVR = Little Vermillion River

Table 3.12. Holding Pond Sediment Sampling Program

Point	Date	Sample Description	Analytical Suites
Holding Pond: North End	3 Nov 94	Black clayey silt, liquid state	Metals and PAH Focused
Holding Pond: Middle	3 Nov 94	Black clay and silt, soft, liquid state	Metals and PAH Focused
Holding Pond: South End	3 Nov 94	Black clay and silt, soft, liquid state	Metals and PAH Focused

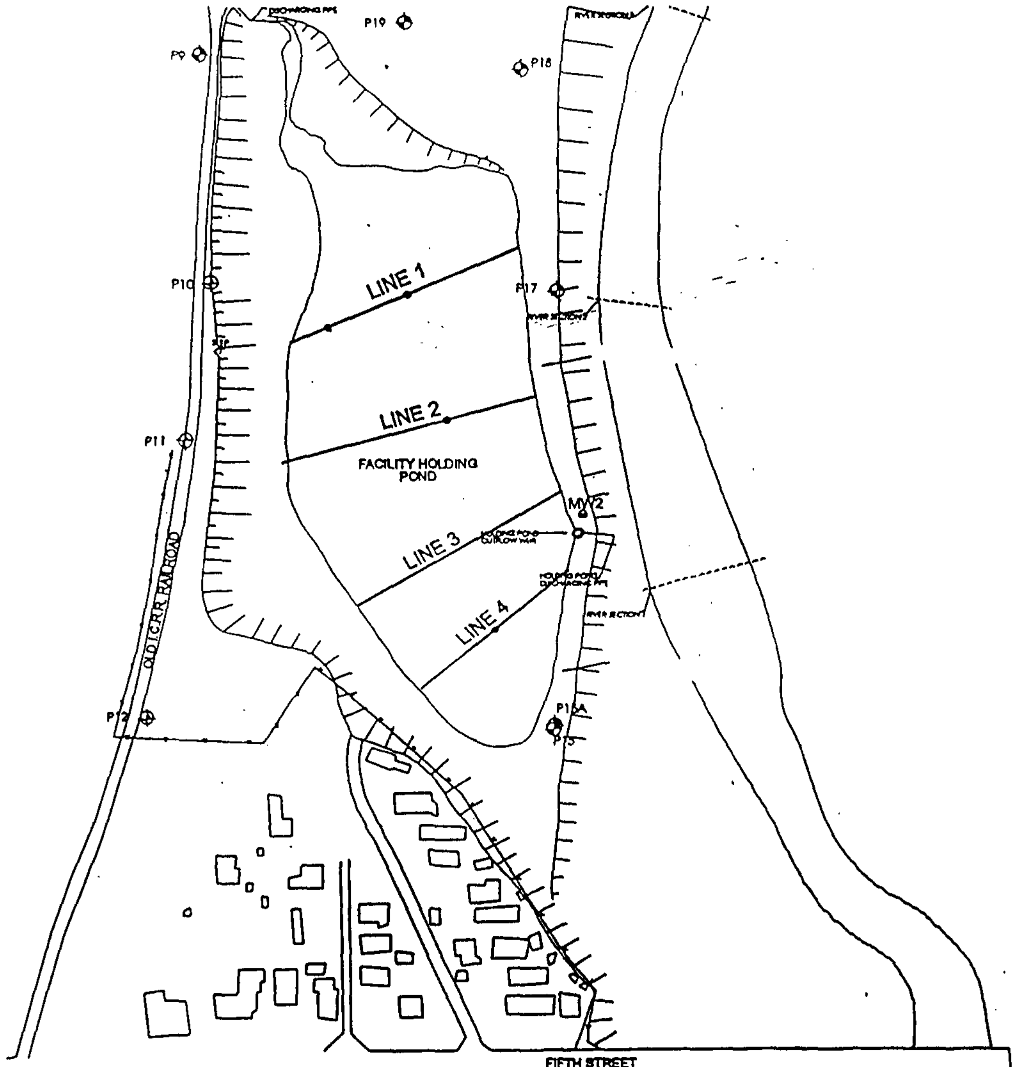


RIVER SEDIMENT SAMPLE LOCATIONS

GEOSYNTEC CONSULTANTS

FIGURE NO.	3-1
PROJECT NO.	FE2167
DOCUMENT NO.	
PAGE NO.	

2167F002 199601081609MR



NOTE: POINTS INDICATE SAMPLING LOCATION.

HOLDING POND SECTION LINES AND SAMPLING LOCATIONS

GEOSYNTEC CONSULTANTS

FIGURE NO.	3-2
PROJECT NO	FE2167
DOCUMENT NO.	
PAGE NO.	

GEOLOGY AND HYDROGEOLOGY

4. GEOLOGY AND HYDROGEOLOGY

4.1 Introduction

The purpose of this section is to develop a comprehensive understanding of the geology, hydrogeology, and flow systems in and through the Phase II Area in order to evaluate constituent mobility. The information presented in Section 4 is based on referenced geologic documents and the findings of the Phase II Investigation described in Section 3 of this report. The remainder of Section 4 is organized as follows:

- the regional setting, including regional geology, regional hydrology, and regional hydrogeology, is described in Section 4.2;
- the geology of the Phase II Area is described in Section 4.3; and
- the Phase II Area hydrogeology and flow systems are described in Section 4.4.

4.2 Regional Setting

4.2.1 Regional Geology

The regional geology of north-central Illinois consists of unconsolidated alluvial and glacial deposits overlying sedimentary rock. The sedimentary rock is of Paleozoic age (600 to 250 million year ago), the glacial and possibly some of the alluvial deposits are of Pleistocene age (2 million to 10,000 years ago), and the rest of the alluvium is of Holocene age (last 10,000 years).

For the purposes of this investigation, the Paleozoic strata can be divided into lower Paleozoic deposits and upper Paleozoic deposits. The lower Paleozoic deposits consist primarily of sandstone, dolomite, and shale, and are on the order of 4,800 ft (1,440 m) thick. The upper Paleozoic deposits, which are entirely of Pennsylvanian age, consist primarily of shale, limestone, sandstone, and coal, and are on the order of

400 ft (120 m) thick. The distinction between lower and upper Paleozoic deposits is significant with respect to the LaSalle Anticline, which is the most important geological structure in the region.

The LaSalle Anticline is a sharp, southwestward-dipping flexure in the lower Paleozoic sedimentary strata. The flexure was formed after deposition of the lower Paleozoic strata but before deposition of the upper Paleozoic strata. The axis of flexure on the northwest to southeast trending anticline is located approximately 1 mi (1.6 km) to the northeast of the site. As a result of this flexure, lower Paleozoic strata that exist at depths of 1,500 ft (450 m) a distance of 1.5 mi (2.5 km) to the southwest of the site are exposed at or near the ground surface at about 1 mi (1.6 km) northeast of the site. However, this sharp flexure does not occur within the upper Paleozoic (Pennsylvanian) strata. The upper Paleozoic deposits merely overlap and thin against the flexure.

During the Mesozoic and early Cenozoic periods in Illinois, emergence of the Paleozoic formations resulted in widespread erosion and production of a low-relief topography. During the Pleistocene Epoch, glaciers advanced over the region, scouring out softer rocks and soils. As the ice melted, large volumes of rock and soil debris were left behind as glacial drift. Glacial drift deposits range up to 600 ft (180 m) in thickness in the region. Based upon water well completion reports submitted to the IEPA, glacial drift ranges from less than 10 ft (3 m) up to 100 ft (30 m) in thickness within a five-mile (8 km) radius of the site. The average thickness of glacial deposits is approximately 40 ft (12 m) within an area bounded to the south by the Illinois River and the east by the Little Vermilion River. South of the Illinois River and west of the Vermilion River, the average thickness of glacial deposits is approximately 60 ft (18 m). Northeast of the site, across the Little Vermilion River, glacial deposits appear to be 10 ft (3 m) thick or less.

The modern distribution of alluvial and glacial deposits is related to the topography of the area. The topography of the LaSalle area consists of fairly flat upland areas away from the Illinois River, a gentle slope toward the Illinois River, and a broad, straight-sided alluvial valley through which the Illinois River meanders. The elevation of the Illinois River floodplain is approximately 450 ft (135 m), while the elevation of the upland areas are greater than approximately 580 to 600 ft (175 to 180 m). In general, glacial deposits are present in the upland areas where elevations are greater than approximately 580 ft (175 m) msl. Below this elevation but outside of the Illinois River floodplain, the Paleozoic deposits lie at the surface.

4.2.2 Regional Hydrology

LaSalle County lies within the Illinois River drainage basin. The Illinois River flows across the central portion of LaSalle County in a westerly direction. Overall, LaSalle County is moderately well drained, although wetlands occur near the headwaters of some upland creeks and in the floodplain of the Illinois River. Important tributaries of the Illinois River include the Fox River, the Vermilion River, and the Little Vermilion River. The latter flows from north to south along the eastern side of the Phase II Area.

4.2.3 Regional Hydrogeology

Aquifers within north-central Illinois consist of sands and gravels occurring within the glacial drift as well as permeable bedrock formations, principally sandstones and dolomites. The City of LaSalle has a well field approximately 0.6 mi (1.0 km) south of the Carus Chemical manufacturing facility. This field produces water from the alluvium of the Illinois River. The wells are about 70 ft (21 m) deep. The City of Peru operates several municipal wells between one and three miles (3 to 5 km) to the west and northwest of the site. These wells produce water from the lower Paleozoic formations at depths below 2,000 ft (610 m).

4.3 Geology of the Phase II Area

4.3.1 Overview

The Phase II Area lies within the deep and narrow valley of the Little Vermilion River. The Phase I Area lies on the bluffs to the west. The width of the valley from bluff to bluff is approximately 1,000 ft (300 m), and the elevation drop from the bluffs to the river is approximately 110 ft (34 m).

The rocks and soils beneath the site were formed as either natural or man-made deposits of sediment and fill material. Each type of deposit has chemical and hydrogeologic properties which are unique and individually significant to the flow and chemical composition of the shallow ground water beneath the site. For this report, these deposits can be divided into six general groups on the basis of age and origin:

- the Pennsylvanian System, which includes the bedrock and residual soils formed upon it;

- the Pleistocene Series, which includes a small lens of glacial deposits along the northwestern edge of the Phase II Area and in the northeastern corner of the Phase I Area.

- the slag pile, which lies between the Little Vermilion River and the ICRR grade;

- the alluvium of the Little Vermilion River, most of which lies buried beneath the slag pile and the holding pond;

- the holding pond berms and sediment; and

- miscellaneous structural fill, which includes the embankments of the ICRR, the emergency storage pond berm, and various deposits between the ICRR grade and the Phase I Area.

Drawing 2 presents the cross section location map. The hydrogeological relationships of these deposits are shown on the cross sections presented in Drawings 3 through 9 and are described in the remainder of this section.

4.3.2 Pennsylvanian System

The Pennsylvanian System constitutes the bedrock and underlies the entire area around the site. Within the area of investigation, the Pennsylvanian System consists of horizontal or nearly horizontal layers of shale and limestone with a few thin beds of coal and sandstone. In the upland areas, a mantle of residual soil has developed within the upper few feet of the Pennsylvanian shales. The Pennsylvanian section, down to the level of the Little Vermilion River, is shown on Drawing 3. The top of the Pennsylvanian system is shown on Drawing 10. The Pennsylvanian System was described in detail in the Phase I report.

In general, the Pennsylvanian System at the site is hundreds of feet thick. The strata directly observed consists of 50 ft (15.2 m) of shale, overlying 26 ft (7.9 m) of limestone, overlying more than 50 ft (15.2 m) of shale. The hydraulic conductivity of the shales is extremely low, except near the ground surface, where weathering has produced residual soils with low hydraulic conductivity. Based on the Phase I Investigations, the weathered shales have hydraulic conductivities on the order of 3×10^{-6} cm/s.

In general, the limestones are effectively non-porous, except where fractures are present. On the basis of outcrop observations, significant fractures occur at a frequency of approximately one fracture every 30 to 100 ft (9 to 30 m). This low recurrence of fractures indicates a low transmissivity for the limestone unit. No karst development was observed, however some dissolution enlargement of fractures along the edge of the Little Vermilion River gorge was observed.

In nearly all areas on and around the site, the limestone is both overlain and underlain by shale. These thick, essentially impermeable shale layers appear to have protected the fractures in the limestone from significant ground-water recharge, and therefore prevented dissolution enlargement. An exception to this may occur at the mouth of the gully beneath the Phase I Area (near MW-1). In this case, erosion of the shale along the axis of the gully may have allowed ground water to percolate downward into underlying fractures in the limestone. As typically occurs where limestone bluffs line river valleys, a short dissolution channel probably developed between the floor of the gully and the edge of the bluff. The existence of such a channel helps explain observations described in Section 4.4 concerning the flow of ground-water from the Phase I Area into the Phase II Area.

4.3.3 Pleistocene Series

The Pleistocene Series is confined to the northeastern corner of the Phase I Area and the northwestern edge of the Phase II Area, where it forms an irregular layer up to approximately 20 ft (6 m) thick. The Pleistocene Series consists of the following lithologies: (i) coarse till; (ii) fine till; (iii) silty clay; and (iv) clean sand. The first three listed lithologies were described in detail in the Phase I report. The clean sand is described in detail in the logs from borings P-3 and P-4 taken during the Phase II Investigation.

In all four types of Pleistocene deposits, ground water flows through intergranular pore spaces, with the hydraulic conductivity determined by the size and abundance of the pores. The coarse till, which has a matrix of poorly sorted sand but little or no silt and clay, is characterized by a moderately high hydraulic conductivity. In monitoring well G-04, the hydraulic conductivity of the coarse till was measured to be approximately 3 x 10^{-3} cm/s. Based upon the geologic observation and classification of the materials, the hydraulic conductivity of the clean sand is estimated also to be on the order of 3 x 10^{-3} cm/s, and that of the silty clay and fine till is estimated to be less than 10^{-5} cm/s [Freeze and Cherry, 1979].

The internal stratigraphy of the Pleistocene deposits is quite complex and appears to vary greatly over short distances and depths. For example, it is likely that the coarse till layer encountered at monitoring well G-04 may be an isolated lens within layers of silty clay and fine till.

4.3.4 Slag Pile

The slag pile is the principal feature of the Phase II Area. The slag pile occupies the space between the ICRR grade and the Little Vermilion River, and extends from beyond the northern property limit of the Phase II Area to the northern end of the holding pond. The slag pile is more than 100 ft (30 m) thick, and is believed to occupy a volume of about 1.5 x 10^6 ft^3 (42,000 m^3). The slag pile is composed primarily of slag from zinc smelting, along with some coal ash, some miscellaneous waste material, and a few layers of topsoil.

Slag is the recrystallized or vitrified silicate and oxide residue from the production of metal from ore. Typically, and as observed at the site, slag ranges in color from moderate red to blackish red and has a highly porous, cindery, vesicular texture similar to scoriaceous lava rock. Much of the slag appears to have become welded into large blocks by its own heat prior to and during deposition. Slag deposits observed in outcrops in the Phase II Area of the site were extremely porous with large, interconnected voids on the order of 0.3 to 1.0 ft (0.1 to 0.3 m) across.

Black, granular material, interpreted as coal ash, was observed as lenses within the slag pile. In general, these lenses have a coarse-grained, well-sorted (i.e. uniform), poorly compacted texture. Based on hardness and appearance, it is believed this material may consist largely of silicon carbide. This material was found to be most abundant in the vicinity of boring P-2, as shown on Drawing 8.

Miscellaneous waste materials were found scattered throughout the slag pile. These materials included bricks, ceramic retorts, and steel. No order was observed in the distribution of these materials. Topsoil layers were present at borings P-2 and P-1. These layers are believed to represent extended periods when deposition was occurring in other areas of the slag pile, thereby allowing vegetation to develop.

Internally, the slag pile consists of imbricated lobes that represent individual loads of dumped slag. Along the river where the slag pile is well exposed, these layers dip steeply toward the river, at what is assumed to be the angle of repose of hot slag. It is not known whether this layering has a significant effect on ground-water flow through the slag.

Based upon slug test and pump test results (see Section 3.3.2), the slag has a hydraulic conductivity greater than 10^{-1} cm/s. Based upon the large size of the pores, it is likely that turbulent flow occurs throughout much of the slag. The apparent lack of significant horizontal layering indicates a low potential for perched layers to be present within the slag.

4.3.5 River Alluvium

In general, the alluvial deposits of the Little Vermilion River consist of clayey gravel with some lenses of sand and some boulders. The alluvium appears to extend across the entire floor of the valley and extends to 40 ft (12 m) in depth. The character of the alluvium is complex primarily as a result of changing industrial activities in the valley. The alluvium in the Phase II Area can be divided into the following units:

- pre-industrial alluvium;
- early industrial alluvium;
- proximal slag alluvium;
- distal slag alluvium;
- washover sand alluvium; and
- floodplain deposits.

Pre-industrial alluvium occurs at the base of the alluvial deposits and ranges up to around 5 ft (1.5 m) in thickness. Pre-industrial alluvium is characterized primarily by limestone gravel with interstitial clay. The clay most likely originated as chunks of shale that were deposited with the gravel and then weathered. The sources of the pre-industrial alluvium are the eroded bedrock and glacial deposits upstream.

Early industrial alluvium overlies the pre-industrial alluvium with a thickness up to 20 ft (6 m) (see boring P-22). Early industrial alluvium consists of two units: (i) clay and silt from the mill pond; and (ii) clayey gravel with coal (Drawing 6). The mill pond clay and silt are confined to the northern end of the Phase II Area, whereas the clayey gravel with coal appears to be present along the entire length of Phase II Area. The lithologies of these units are described in detail in the boring logs for piezometers P-1 and P-22.

Proximal slag alluvium overlies the pre-industrial alluvium and is present in the immediate vicinity of the slag pile. Proximal slag alluvium is material that has been eroded from the slag pile and deposited in the immediate proximity of the pile. Proximal slag alluvium is characterized primarily by gravel to boulder-sized pieces of slag with some limestone boulders. The limestone boulders are from the undercutting of the east wall of the gorge by the new channel of the river. Sand and silt are generally absent in the proximal slag alluvium and interstitial clay is uncommon. The proximal slag alluvium generally grades upward or laterally into the slag pile itself.

Distal slag alluvium also overlies the pre-industrial alluvium, but extends from the southern end of the slag pile downstream to at least the Fifth Street Bridge. Distal slag alluvium is material that has eroded from the slag pile and then been transported some distance away by the river. The thickness of the distal alluvium is not known precisely, but is estimated to be approximately 10 ft (3 m). The distal slag alluvium consists of a framework of gravel to boulder-sized pieces of slag infilled with sand, clay, and a little silt.

The washover sand alluvium (i.e., sand alluvium) is present beneath the berm and at least in the eastern half of the holding pond. Deposits of this unit were encountered during boring advancement for monitoring well MW-2 and piezometer P-17. This unit consists primarily of gray silty sand, and at monitoring well MW-2, has a thickness of approximately 25 ft (7.5 m). This unit is analogous to natural levee or sandbar deposits that form along lowland rivers. Such levees confine coarse sediment to the river channel but allow fine sand and silt to wash over them during floods. As the sand washes over the levee, it forms a large sandbar.

Floodplain deposits consisting of silty sand are present upstream of the slag pile and downstream of the holding pond, where the valley is sufficiently wide to accommodate a floodplain. Downstream from the holding pond, floodplain deposits were observed in outcrop to form a thin [less than 1 ft (0.3 m)] layer overlying the distal slag alluvium. Near the upstream end of the Phase I Area, where the river is presently impounded, the floodplain deposits were observed to be more than 4 ft (1.2 m) thick.

Based upon the appearance of the alluvium and the results of pump tests and slug tests (see Section 3.3.2), the majority of the alluvium probably has a hydraulic conductivity of between 3 x 10^{-3} cm/s and 1 x 10^{-2} cm/s. A significant exception to this is the proximal slag alluvium, which is expected to have a hydraulic conductivity ranging between the alluvium and slag units (i.e., 3 x 10^{-2} cm/s) (see Section 4.3.4).

4.3.6 Holding Pond Berm and Sediment

The two main geological components of the holding pond are the berm along the eastern side and the sediments within the pond. The berm consists of slag overlain by a thin veneer of topsoil. At the southern end of the pond, the slag is also overlain by a layer of high-plasticity clay.

The holding pond sediments were found to consist of a layer of very soft silt and clay overlying a denser substrate. In general, the silt and clay layer was black and occasionally sulfurous, and contained abundant vegetative matter, especially organic matter. The black color and sulfurous odor is attributable to anaerobic decomposition of leaves. The stratigraphy of the holding pond sediments is shown on Cross Section J (Drawing 6).

The hydraulic conductivity of the holding pond sediment was not measured (see Section 3.5.3). Based upon the fine-grained texture of the deposits, however, a hydraulic conductivity on the order of 10^{-5} cm/s appears reasonable [Freeze & Cherry, 1979].

4.3.7 Miscellaneous Structural Fill

The term "miscellaneous structural fill" includes embankments for the ICRR grade, the emergency storage pond berm, fill between the Phase I Area and the ICRR grade, and the gully fill in the Phase I Area. With the exception of the emergency storage pond, these fills appear to have been constructed using locally derived soil, cinders, and industrial waste. According to Jim Miller of Carus, the emergency storage pond was constructed from specified low permeability clay soil from an off site borrow source.

4.4 Site Hydrogeology

The Carus Chemical Company site is underlain by a multicomponent shallow flow system. This shallow flow system is recharged from three sources: (i) precipitation; (ii) river water from upstream; and (iii) fugitive losses of non-contact cooling water from the Carus Chemical Company plant. Discharge from the shallow flow system is believed to be limited to the Little Vermilion River system.

The remainder of this section contains descriptions of the lower confining layer followed by the four components of the shallow flow system. These components are defined as follows:

- the gully-fill system, which occurs in the infilled gully described in the Phase I Investigation;
- the holding pond system, which includes the holding pond and holding pond sediments;
- the alluvial system, which includes the Little Vermilion River, associated alluvium, and overlying slag;
- the upland-soil system, which occurs in the residual soils beyond the limits of the gully fill system.

Drawing 10 is a map of the shallow flow system beneath the Phase I, Phase II, and adjacent areas. The potentiometric contours shown are for the gully-fill and alluvial systems. Contours extending laterally from the gully-fill into the upland-soil system are also shown. Contours for the holding pond system are not shown because the gradients are vertical. Contours are not shown for the sides of the Little Vermilion Gorge because water in this area is limited to overland flow and seepage through the limited topsoil.

4.4.1 Lower Confining Layer

The top of the lower confining layer marks the base of the shallow flow system. In general, the top of the lower confining layer corresponds to the top of the Pennsylvanian bedrock or, where present, the Pleistocene deposits. Drawing 10 is a contour map of the base of the shallow flow system. (As mapped, the upland soil flow system is actually contained within the upper few feet of the lower confining layer. This practice is justified because of the overall low transmissivity of the upland soil unit (see Section 4.4.5) and because the boundary, as mapped, can be defined much more precisely.)

4.4.2 Gully-Fill Flow System

Recognition of the gully-fill system was a key finding of the Phase I Investigation. In summary, from the Phase I Investigation, boring logs indicate the gully-fill system is located in the east-central part of the Phase I Area and occurs in industrial-age fill deposits within a pre-industrial gully. The fill materials consist of two main components: (i) a buried berm of slag along the eastern side of the gully; and (ii) general fill, consisting of reworked shale (i.e. excavated soil) and miscellaneous material.

Recharge to the gully-fill system occurs mainly from fugitive losses of used cooling water from the plant sewer. Discharge from the gully-fill system occurs as ground-water flow mainly through the former mouth of the gully and directly down into the alluvial flow system. Secondary discharge occurs laterally into the surrounding soil system and through a few small seeps in the eastern face of the embankment between the main plant area and the ICRR grade. Based upon field observations and pump test data from the Phase II Investigation, and the high volume of flow through and the age of the plant sewer, GeoSyntec now believes that losses of used non-contact cooling water from the plant sewer exceed the minimum 7.5 gal/min (0.5 L/s) that was calculated in the Phase I Investigation.

At the time of the Phase I Investigation, a large leak had developed and was being repaired at the western end of the infilled gully. In the Phase I report, it was speculated that this leak might have been the main source of water for the gully-fill system. Comparison of water levels in monitoring well G-05 from 17 November 1993 and 10 October 1994 indicate no significant change in the saturation of the gully-fill system. The 1993 water level in monitoring well G-05 was 562.23 ft (171.40 m) above sea level, and the 1994 water level was 562.15 ft (171.34 m). This suggests that there may be significant fugitive loss from the sewer pipe occurring along its length.

4.4.3 Holding Pond Flow System

The holding pond is a perched flow system that overlies the alluvial flow system. Recharge to the holding pond system is mainly from the outfall of the plant sewer, and discharge is mainly from the NPDES outfall into the Little Vermilion River. Secondary sources of recharge include direct and runoff precipitation and the boiler blowdown pipe, which parallels the plant sewer. Secondary sources of discharge include direct evaporation, transpiration by plants along the edge of the pond, and potential leakage through the bottom of the pond into the alluvial flow system.

Leakage from the holding pond flow system into the alluvial flow system is best indicated by the nature of water that was purged from piezometers P-17 and MW-2. The water purged from these two piezometers during sampling had properties more similar to the holding pond than to the rest of the alluvial system (see Table 3-10). Furthermore, the 30 ft (10 m) difference in hydraulic head between the holding pond and river provides the energy necessary to drive water downward through the pond sediments.

4.4.4 Alluvial Flow System

The alluvial flow system occurs within the alluvial and slag deposits in the bottom of the Little Vermilion River gorge. Unlike the other shallow flow systems described in this report, the alluvial flow system is not limited to small areas on or around the site, but extends through the site, from the head waters of the Little Vermilion River to the confluence with the Illinois River alluvial system. The lateral extent of the Little Vermilion flow system is defined as the intersection of the water table with the lower confining layer, as mapped on Drawing 10.

The alluvial flow system is dominated by the flow of the Little Vermilion River. Comparison of river flow to discharge from the outfall pond (see Sections 3.4.2 and 3.5.3) indicate that the outfall pond contributes approximately 19.3 percent of the flow for the Little Vermilion system. Comparison of upstream flow to downstream flow (Table 3.5) indicates that the net contribution to flow from the Carus Chemical Company Manufacturing site is approximately 53 percent of the total downstream flow. These percentages are likely to approximate the maximum yearly percentage of contribution from non-river sources because the autumn is typically the season of lowest river flow. Furthermore, the upstream flow measurement was taken at the Carus Chemical Company property boundary, which is slightly south of the slag pile. Therefore, some flow from the river may be diverted through the slag pile. The amount of diverted flow is not known. Consequently, it is believed that the calculated contribution to flow from the Carus Chemical Company Manufacturing site is somewhat overestimated.

4.4.5 Upland-Soil Flow System

The upland-soil flow system occurs in residual soils that lie to the north, south, and west of the gully-fill flow system. These residual soils occur in both the

Pennsylvanian shales and the Pleistocene deposits. Recharge to the upland-soil flow system appears to occur from a combination of precipitation and lateral flow out of the gully-fill system. Discharge most likely occurs through evapotranspiration, lateral discharge into the gully-fill system, and seepage toward and into the Little Vermilion valley.

In general, the transmissivity of the upland soil flow system is quite low. Compared to the other flow systems at the site, the transmissivity is negligible. A minor exception to this occurs in the northeastern corner of the Phase I Area, where a lens of Pleistocene sand and gravel (i.e., coarse fill) is present.

Sand and gravel (formerly described as coarse fill) is present as a lens in the northeastern corner of the Phase I Area. The lens was observed to be at monitoring well G-04, where it is 6 ft (2 m) thick. The areal extent of this lens is well defined from borehole data on the south and east sides; the lens is present in monitoring well G-04, but is absent in soil borings C-5 and C-6 and piezometer P-6. The areal extent of the lens north of the Carus Chemical Company property has not been defined or investigated. Water-level measurements in monitoring wells G-04 and G-103, and in piezometer P-6, provide additional information about the limits of this lens. The high water levels measured suggest that a lens of limited area that although having a high hydraulic conductivity, is hydraulically isolated from other high conductivity soils.

ANALYTICAL RESULTS
AND DATA EVALUATION

5. ANALYTICAL RESULTS AND DATA EVALUATION

5.1 Overview

This section presents the laboratory analytical results for the Phase II Investigation of the Carus facility. Results are presented separately for each of the following: (i) soil (Section 5.2); (ii) ground water (Section 5.3); (iii) river water and sediment (Section 5.4); and (iv) the holding pond (Section 5.5). Relevant data collected during the IEPA SSI, GeoSyntec's PSI, and the Phase I Site Investigation are presented in each section to complement the Phase II test results.

5.2 Soil Analyses

5.2.1 Previous Results -- Soil Samples

As part of the SSI and as discussed in Section 2.5.3 of this report, on 20 and 21 November 1991, four surface soil samples (X102 through X105) were collected at the site and one background surface soil sample (X101) was collected from Hegeler Park, located approximately 0.5 mi (0.8 km) northwest of the Carus Chemical Company manufacturing facility. The on-site surface samples collected during the IEPA SSI included: (i) two samples located east of the railroad embankment, where slag and other materials had been disposed (X103 and X104); (ii) one sample located near the southeast corner of the manufacturing area (X105, Phase I Area); and (iii) one sample located adjacent to a drum and filter bag storage area (X102, Phase I Area). The results are shown in Table 5.1 and indicate that:

- inorganic chemical constituents were present in soil samples collected from the Carus site at concentrations greater than inferred background concentrations detected at the off-site location;

- arsenic, barium, cadmium, calcium, copper, lead, magnesium, manganese, mercury, nickel, potassium, silver, sulfate, and zinc were detected at concentrations above inferred background; and

- the highest concentrations detected on the Carus site when compared to background were of lead and zinc.

During the GeoSyntec PSI, analyses for RCRA metals using the TCLP were performed on soil samples collected. The TCLP results are shown in Table 5.2 and indicate that:

- most of the metals were either not detected or were detected at concentrations well below IHWMR §721.24 regulatory limits for hazardous waste;

- cadmium was detected at one location at 1.15 mg/L, which slightly exceeds the IHWMR TCLP limit of 1 mg/L for cadmium, for a sample collected from an area where sinter had been deposited; and

- lead was detected at one location at 5.21 mg/L, which slightly exceeds the IHWMR TCLP limit of 5 mg/L for lead, for a sample collected from the slag deposit area.

During GeoSyntec's Phase I Site Investigation, results of laboratory chemical analyses for soil samples collected indicate that elevated concentrations of inorganic constituents were detected. The analytical results of the Phase I Site Investigation for soil are presented in Tables 5.3 and 5.4. Total results (Table 5.3) indicate that samples collected from areas containing slag, sinter, and other industrial by-products associated with past activities adjacent to the site were present at concentrations exceeding inferred background levels. However, TCLP analyses (Table 5.4) performed as part of the Phase I Site Investigation indicate that all of the samples analyzed were below IHWMR regulatory limits.

5.2.2 Phase II Investigation Results -- Soil Samples

Eighteen soil borings were drilled as part of the Phase II Investigation (Drawing 1). Soil samples were collected for laboratory analyses of total metals and other inorganics, and also for metals using TCLP analysis. The results for the total metals analysis of soil samples collected are presented in Table 5.5 and Drawing 11, and results for the TCLP analysis are presented in Table 5.6 and Drawing 12.

Results of the TCLP analyses presented in Table 5.6 indicate that three samples exceed the IHWMR limits (1 mg/L for cadmium and 5 mg/L for lead). TCLP values exceeded the IHWMR limits for the following locations: (i) boring P-15A, depth of 20 ft (6 m), lead concentration of 5.8 mg/L; (ii) boring P-17, depth of 10 ft (3 m), lead concentration of 7.2 mg/L; and (iii) boring P-19, depth of 42 ft (13 m), cadmium concentration of 1.1 mg/L.

5.3 Ground-Water Analyses

5.3.1 Previous Results -- Ground-Water Samples

Ground-water results from the IEPA SSI samples (Table 5.7) indicate that several inorganic constituents were detected at concentrations exceeding Illinois ground-water quality standards for Class II ground water. Concentrations in excess of Class II standards for barium, iron, lead, manganese, zinc, and sulfate were detected. According to Section 620.420(a)(3) of 35 IAC, Class II standards for all of these constituents, with the exception of lead, do not apply for ground water within fill material. As described in 620.420(a)(4) of 35 IAC, fill material includes clean earthen materials, slag, ash, clean demolition debris, or other similar materials. Detected lead concentrations exceeded Class II standards in the following ground-water monitoring wells: G103 (0.179 mg/L), G104 (0.448 mg/L), and G106 (0.109 mg/L). The Class II standard for lead is 0.1 mg/L.

Results of ground-water quality analysis from GeoSyntec's PSI (Table 5.8) indicate that lead was present in monitoring well MW-2 at a concentration of 0.11 mg/L, which slightly exceeds the Class II water quality standard of 0.1 mg/L. All other chemical constituents analyzed were either not detected or were detected at concentrations below Class II ground-water quality standards.

Ground-water results for GeoSyntec's Phase I Site Investigation (Table 5.9 and 5.10) indicate that chemical constituents exceeding Class II ground-water quality standards were detected. These exceedances occurred for the following constituents and monitoring wells:

- Benzene was detected in monitoring well G-04 (0.55 mg/L) exceeding the Class II standard of 0.005 mg/L.

- Total iron was detected in monitoring wells G-05 (11.2 mg/L), MW-1 (7.3 mg/L), and MW-2 (137 mg/L) exceeding the Class II standard of 5 mg/L. However, the Class II standard for iron does not apply to ground water within slag.

- Total lead was detected in monitoring wells G-05 (2.18 mg/L) and MW-2 (0.303 mg/L) exceeding the Class II standard of 0.1 mg/L.

- Total manganese was detected in monitoring well MW-2 (16.9 mg/L) exceeding the Class II standard of 10 mg/L. However, the Class II standard for manganese does not apply to ground water within slag.

- Sulfate was detected in monitoring well G-02 (1,300 mg/L), G-05 (885 mg/L), G-101 (610 mg/L), G-103 (908 mg/L), G-106 (1,520 mg/L), MW-1 (1,480 mg/L), and MW-2 (1,460 mg/L) exceeding the Class II standard of 400 mg/L. However, the Class II standard for sulfate does not apply to ground water within slag.

- Total zinc was detected in monitoring wells G-106 (10.2 mg/L) and MW-2 (26.4 mg/L) exceeding the Class II standard of 10 mg/L. However, the Class II standard for zinc does not apply to ground water within slag.

5.3.2 Phase II Investigation Results -- Ground-Water Samples

Ground-water samples were collected during the Phase II Investigation from both newly installed piezometers and selected existing monitoring wells. All samples were analyzed for the metals focused suite; samples from piezometer P-6 and monitoring well G-04 were also analyzed for the petroleum focused suite as well. Samples for metals analysis were filtered using a 5μm filter where water was visually turbid after purging.

Results of the ground-water sampling program for the Phase II Investigation are summarized in Tables 5.11 and 5.12. Drawing 13 provides a summary of the results. The results indicate that concentrations of some constituents were detected in excess of Class II ground-water quality standards, as follows:

- Total cadmium was detected in piezometers P-1 (2.2 mg/L), P-18 (0.562 mg/L), and P-19 (0.072 mg/L) exceeding the Class II standard of 0.050 mg/L.

- Total iron was detected in piezometers P-7 (14.2 mg/L), P-17 (5.38 mg/L), and P-18 (17.3 mg/L), and monitoring well G-04 (12.6 mg/L) exceeding the Class II standard of 5 mg/L. However, the Class II standard does not apply to ground water within slag.

- Total manganese was detected in piezometers P-1 (12.4 mg/L), P-6 (25.3 mg/L), P-7 (20.7 mg/L), and P-18 (11.5 mg/L), and monitoring well MW-1 (10.8 mg/L) exceeding the Class II standard of 10 mg/L. However, the Class II standard does not apply to ground water within slag.

- Total zinc was detected in piezometers P-1 (831 mg/L) and P-18 (382 mg/L) exceeding the Class II standard of 10 mg/L. However, the Class II standard does not apply to ground water within slag.

- Sulfate was detected in piezometers P-1 (4,440 mg/L), P-6 (1,890 mg/L), P-7 (1,890 mg/L), P-9 (1,510 mg/L), P-15 (502 mg/L), P-17 (1,350 mg/L), P-18

(2,450 mg/L), and P-19 (1,300 mg/L), monitoring wells MW-1 (1,590 mg/L), MW-1DP (1,640 mg/L), MW-2 (1,170 mg/L), and G-04 (2,990 mg/L) exceeding the Class II standard of 400 mg/L. However, the Class II standard does not apply to ground water within slag.

Benzene was detected (0.87 mg/L) in the sample collected from monitoring well G-04 exceeding the Class II ground-water quality standard of 0.005 mg/L. Other VOCs detected (e.g., ethylbenzene, toluene, and xylene) were below Class II standards. Hydrocarbon analysis results are presented in Table 5.12.

5.4 Little Vermilion River Investigation

5.4.1 Previous Investigations

During the IEPA SSI (20 and 21 November 1991) and the PSI (3 October 1992) conducted by GeoSyntec, river sediments were analyzed. The results from these investigations are summarized in Table 5.13. No river sediments were located within the geographical scope of the Phase I Investigation performed by GeoSyntec.

5.4.2 Overview of Phase II Little Vermilion River Investigation

Water and sediment samples were collected from the Little Vermilion River at the three locations shown on Figure 3-1 and described below:

- Quarry Bridge, upstream from all industrial activities associated with the manufacture of zinc or manganese products;

- Section Line, the northern property line of Carus Chemical Company; and

- Fifth Street Bridge, which is downstream of all Carus Chemical Company operations.

These sample locations were chosen in order to provide a means of comparing the change in metals concentrations in river water and underlying sediment as the river approached and flowed past the Carus Chemical Company property.

5.4.3 River Water Results/Phase II Investigation

River-water analytical results are presented in Table 5.14. Drawing 13 shows the location and the results of the river water sampling. The results for river water samples indicate that several constituents were detected at concentrations in excess of general use water quality standards listed in Section 302 of 35 IAC. These standards apply to waters of the State for which there is no specific designation, which would apply to the Little Vermilion River. Iron concentrations were detected in samples collected from all three river sampling locations exceeding the surface-water standard of 1 mg/L for iron. The chronic standard for cyanide of 5.2 μg/l was exceeded in the sample collected far upstream of the site (Quarry Bridge) and at the upstream boundary of the site (Section Line); cyanide was not detected above the reported detection limit at the downstream sample location. Manganese concentrations for the Section Line sample exceeded the standard of 1 mg/L; manganese concentrations in these samples were approximately ten times higher than samples collected further upstream and downstream. The analytical results indicate that the Carus Chemical Company manufacturing facility is not adversely impacting river water quality.

5.4.4 River Sediment Results

River sediment samples were collected from the same locations as the river water samples. These sediment samples were submitted for analysis of total metals and also for metals using the TCLP. The results of the total analysis are presented in Table 5.15 and are summarized below:

- Total concentrations of iron are higher upstream of the site (i.e., at the Quarry Bridge and the Section Line) (41,500 mg/kg and 16,100 mg/kg) when compared to results for the downstream location (9,990 mg/kg).

- Total concentrations of zinc are higher upstream of the site (1,400 mg/kg and 175 mg/kg) when compared to results for the downstream location (598 mg/kg).

- Total concentrations of manganese are higher upstream of the site (662 mg/kg and 584 mg/kg) when compared to results for the downstream location (313 mg/kg).

Based on the TCLP results, there is potential for the sediments to generate river water concentrations in excess of general use water quality standards (Section 302 of 35 IAC). When the TCLP results are compared to the river water results it appears that the potential for impacts to water from the sediments is low. The TCLP results are of limited use in predicting potential impacts to river water partially due to the differences in pH between the two waters (i.e., the TCLP extraction water and the river water). TCLP involves extraction of metals from soil using a relatively acidic pH solution (pH <5) compared to the slightly alkaline river water pH (approximately 8) measured during the Phase II Investigation. Moreover, the results further indicate that the Carus Chemical Company manufacturing facility is not adversely impacting river sediment quality.

5.5 <u>Holding Pond Investigation</u>

5.5.1 Previous Results - Holding Pond

During the IEPA SSI, two sediment samples were obtained from the holding pond (Table 5.16). As indicated in Table 5.16, several organics and metals were detected.

During the Phase I Investigation, GeoSyntec collected a surface-water sample from the holding pond near the top of the pipe which discharges water to the Little Vermilion River under a NPDES permit. This discharge point represents the point of compliance for the Carus Chemical Company NPDES permit. The results for the sample indicated relatively low concentrations of the chemical constituents analyzed (Table 5.9). Overall, concentrations for metals and sulfate were significantly lower than those detected in the ground-water sample collected from monitoring well MW-2 during the IEPA SSI (October 1992) and the Phase I Investigation. Monitoring well MW-2 is located within the berm in close proximity to the outfall pipe.

5.5.2 Phase II Investigation Results - Holding Pond

GeoSyntec collected three sediment samples and one duplicate from the holding pond during the Phase II Investigation, as shown on Figure 3-2. The samples were submitted for total and TCLP analyses of metals and for the PAH suite of constituents. The results of the total metals analysis are presented in Table 5.17, the TCLP results are presented in Table 5.18, and the PAH results are presented in Table 5.19.

Tables 5.17 and 5.18 indicate that metals (i.e., barium, cadmium, chromium, iron, lead, manganese, mercury, nickel, and zinc) by total and TCLP analyses were detected in one or more of the sediment samples. Table 5.19 indicates that no PAHs were detected in the holding pond sediment samples.

Table 5.1. Results of Total Chemical Analyses for Detected Parameters, Soil Samples (SSI) (20 and 21 November 1991)

PARAMETER	X101 Background Sample	X102 Drum and Filter Bag Storage Area	X103 Northern Boundary Fence/East of Carus Property (Slag)	X104 West Bank of LVR (Slag)	X105 Southeast Corner of Carus Manufacturing Facility
Aluminum	18,400	-	-	-	-
Arsenic	15.3	-	245	-	-
Barium	148	-	820	-	-
Cadmium	13.4	-	40.5	70.7	-
Calcium	4,890	64,400	32,200	-	54,900
Copper	28.6	409	278	417	-
Lead	80.8	-	38,700	730	-
Magnesium	2,580	35,600	-	-	19,700
Manganese	804	118,000	-	2,510	12,700
Mercury	<0.095	-	-	1.3	-
Nickel	14.1	44.7	-	-	-
Potassium	1,790	-	-	-	6,810
Silver	<1.5	20.6	-	-	-
Zinc	1,200	-	-	43,700	-
Sulfate	10	254	274	89.5	296

Results in mg/kg
- indicates below detection limit

Table 5.2. Results of TCLP Chemical Analyses for the Eight RCRA Metals (PSI) (6 and 7 October 1992)

PARAMETER	REGULATORY LIMIT	B12/S1 (Slag) (mg/l)	B12/S2 (Slag) (mg/l)	GW2/S1 (Slag) (mg/l)	GW1/S1 (Slag) (mg/l)	B6/S1 (Sinter) (mg/l)	B3/S1 (Sinter) (mg/l)
Arsenic	5.0	<0.001	<0.001	0.060	<0.001	<0.001	<0.001
Barium	100	<0.10	0.24	0.64	0.26	1.06	0.26
Cadmium	1.0	0.048	0.050	0.430	0.214	0.622	**1.15**
Chromium	5.0	<0.010	0.013	0.041	0.014	<0.010	<0.010
Lead	5.0	1.09	<0.10	**5.21**	<0.10	0.43	0.38
Mercury	0.2	<0.002	<0.002	0.002	<0.002	<0.002	<0.002
Selenium	1.0	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Silver	5.0	0.032	0.015	0.027	0.013	0.023	0.016

[1] Regulatory limits per Illinois Hazardous Waste Management Regulation §721.24.
Bold indicates exceedance of IHWMR limit.

Table 5.3 Phase I Site Investigation
Carus Chemical Company
Soil Total Metals Analysis

Parameter	Boring Hole	G-03	G-03	C-9	C-9	C-11	C-11	C-11	C-8	C-5	C-10	C-10
	Depth (ft)	5	15	0	7	0	10	15	0	3	0	7
Barium		179	19.9	29.3	81.9	217	79.9	59.2	25.6	53	190	107
Cadmium		0.93 U	0.97	0.9 U	8.3	38.3	2.4	20.9	0.9 U	2.7	9.8	8.4
Chromium		26.8	23.1	16.6	22.6	22.1	6.1	40	9.8	14.4	44.2	20.7
Iron		25700	8.2	14300	41000	59100	9980	18600	16700	16400	20000	18700
Lead		20.9	2.9	6.2	79.1	3660	77.4	510	14.6	18.6	190	225
Manganese		417	1560	1530	81	1480	122	1440	395	600	3980	1350
Mercury		0.12 U	0.1 U	0.11 U	0.11 U	1.8	0.11 U	0.12 U	0.11 U	0.11 U	0.76	0.12 U
Nickel		29.4	27.2	30.4 B	16.8	21.8	7.2	48.6	22.2	29.4	37.1	36.7
Zinc		45.5	39.4	49.1	506	8550	2160	390	71.7	443	2390	4130
Cyanide		0.53 U	0.52 U	0.55 U	0.54 U	0.56 U	0.52 U	0.6 U	0.53 U	0.57 U	0.6 U	0.61 U
Bicarbonate		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Carbonate		NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sulfate		498	527	767	8640	10800	4160	1830	1070	479	637	503
Sulfide		8.4 U	5.7	5.7 U	16.7	5.7	5.8	5.6 U	19.7	8.4 U	5.6 U	5.7 U
Soil Nature		weathered green shale	red shale	limestone rd. pavement	slag	limestone rd. pavement	slag	shale	lagoon liner	pleistocene clay	limestone rd. pavement	reworked shale
Grain Size		clay	clay	sandy gravel	silty sandy gravel	sandy gravel	silty sandy gravel	clay	gravelly clay	clay	sandy gravel	clay

Notes:
Concentrations are given in mg/kg.
U indicates that constituent concentration was below the indicated detection limit.
NA indicates that analysis for that constituent was not done.

Table 5.4 Phase I Site Investigation
Carus Chemical Company
Soil TCLP Metals Analysis

Parameter	Boring Hole	G-03	G-03	C-9	C-9	C-11	C-11	C-11	C-8	C-5	C-10	C-10	Reg. Limit
	Depth (ft)	5	15	0	7	0	10	15	0	3	0	7	
Barium		2410	422	1270	82.5	177	126	86.3	516	809	545	1640	10000
Cadmium		4 U	4 U	4 U	108	445	125	7.5	5.3	4 U	16.4	83.3	1000
Chromium		5 U	5 U	5 U	5.5	5 U	5 U	5 U	5 U	5 U	5 U	5 U	5000
Iron		75 U	75 U	75 U	3170	75 U	190	75 U	75 U	75 U	75 U	75 U	
Lead		30 U	30 U	30 U	30 U	1780	567	30 U	30 U	30 U	30 U	120	5000
Manganese		1810	6350	6570	3000	5910	1390	819	2640	5200	34.9	4020	
Mercury		0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	200
Nickel		10 U	10 U	10 U	26.8	11.4	30.1	10 U	33	23.3	12.2	13	
Zinc		277	66.2	87.9	2780	69100	100000	84.4	118	161	1640	7390	
Soil Nature		weathered green shale	red shale	limestone rd. pavement	slag	limestone rd. pavement	slag	shale	lagoon liner	pleistocene clay	limestone rd. pavement	reworked shale	
Grain Size		clay	clay	sandy gravel	silty sandy gravel	sandy gravel	silty sandy gravel	clay	gravelly clay	clay	sandy gravel	clay	

Notes:
Concentrations are given in ug/l.
U indicates that constituent concentration was below the indicated detection limit.
Regulatory limits per IHWMR 721.24.

Table 5.5 Phase II Investigation
Carus Chemical Company
Soil Total Metals Analysis

Parameter	Boring Hole	P-1		P-1		P-2		P-2		P-2		P-15A		P-17		P-17		P-18		X101	
	Depth (ft)	21		80		19		42		42		20		10		42		39		BKGND	
Barium		161		54.5		152		80.4		84.6		258		236		189		608		148	
Cadmium		1.9		9.5		228		8.4		8.1		49.5		51.5		45.4		22.9		13.4	
Chromium		6.3		12.9		19.3		27.3		26.6		37.1		97.5		11.7		22			
Iron		14100		24500		35100		97800		94600		33000		55800		60300		54900			
Lead		1470		2.1		2300		267		261		2340		1400		47.9		290		80.8	
Manganese		38.1		185		1170		23.6		28.1		40600		1500		2030		2280		804	
Mercury		0.12	U	0.11	U	0.11	U	0.12	U	0.11	U	2.3		0.42		0.12	U	0.11	U	0.095	U
Nickel		10.5		75.1		9.1	B	13.3		15.1		53.1		88.7		37.7		65.5		14.1	
Zinc		1090		8860		5400		488		489		21600		15100		21800		9700		1200	
Cyanide		0.55	U	0.53	U	0.5	U	0.53	U	0.74		0.59	U	0.56	U	0.6	U	0.45	U		
Bicarbonate		90.4		470		374		93.2		96		773		376		909		191			
Carbonate		0.009		0.003		1.5		0.001		0.001		7.3		11.2		17.5		0.52			
Sulfate		23200		19800		5990		12500		12100		176		289		774		3080		10	
Sulfide		24	U	21.3	U	22.8	U	23.2		23.4	U	547		20.9	U	380		21.6	U		
Soil Nature		red shale and slag		slag		org. soil in slag		shaley sand in slag				slag		slag		recent alluvium		slag			
Grain Size		clayey sand some gravel		sandy gravel		sandy silty clay		silty sand				silty sandy gravel		silty sandy gravel		gravelly sand		gravelly silty sand			
Dry/Moist/Wet		dry		dry		moist		dry				dry		dry		wet		dry			

Notes:
Concentrations are given in mg/kg.
U indicates that constituent concentration was below the indicated detection limit.
B indicates that constituent concentration was between the detection limit and the contract required detection limit.

Table 5.5 (Continued) Phase II Investigation
Carus Chemical Company
Soil Total Metals Analysis

Parameter	Boring Hole	P-19		P-19		P-21		P-21		P-21		P-21		P-22		P-22		X101	
	Depth (ft)	20		42		2.5		21		41		60		41		106		BKGND	
Barium		49.8		16.7	B	471		124		117		65.4		136		32	B	148	
Cadmium		6.1		15.1		6.3		2.1		4.6		18.2		2.6		7.2		13.4	
Chromium		6.7		21.8		4		41.1		2.8		4.1		8.6		8.7			
Iron		10600		55700		60800		209000		7920		5240		26900		39700			
Lead		23		34.1		3850		221		99.3		75.5		48.3		5.5		80.8	
Manganese		56.5		217		95.6		203		50.2		66.8		81.9		859		804	
Mercury		0.1	U	0.12	U	0.11	U	0.11	U	0.15		0.16		0.1	U	0.12	U	0.095	U
Nickel		19.4		41		41.3		24.4		4.4	U	4.9	B	16.2		19.9		14.1	
Zinc		9120		3000		26100		2960		852		1270		3770		687		1200	
Cyanide		0.52	U	0.61	U	0.53	U	0.55	U	0.53	U	0.54	U	0.48	U	0.45	U		
Bicarbonate		193		957		191		479		183		185		1050		2610			
Carbonate		0.052		0.73		0.021		0.057		0.014		0.025		0.12		302			
Sulfate		3580		3990		3100		11500		12900		9300		6120		472		10	
Sulfide		24.1		129		23	U	78.3		12.5		23.9		20.8	U	22.4			
Soil Nature		clay and slag		slag		slag		slag		slag		slag		slag		alluvium			
Grain Size		gravel to sand		grayish red		sandy clayey silt		gravelly sand		gravelly sand		gravelly sand		gravelly sand		clayey gravel			
Dry/Moist/Wet		dry		dry		dry		dry		dry		dry		dry		wet			

Notes:
Concentrations are given in mg/kg.
U indicates that constituent concentration was below the indicated detection limit.
B indicates that constituent concentration was between the detection limit and the contract required detection limit.

Table 5.6 Phase II Site Investigation
Carus Chemical Company
Soil TCLP Metals Analysis

Parameter	Boring Hole	P-1		P-1		P-2		P-2		P-2 DP		P-15A		P-17		P-17		P-18		Reg. Limit
	Depth (ft)	21		80		19		42		42		20		10		42		39		
Barium		55.2	B	78	B	125	B	78	B	78	B	1960		1470		923		248		10000
Cadmium		27.5		213		249		144		137		173		789		95.6		327		1000
Chromium		5	U	12.8		5	U	5	U	5	U	25		20.4		5	U	6.8	B	5000
Iron		50	U	5100		50	U	221		339		227		146		194		193		
Lead		3410		23.3		630		20	U	20	U	5770		7230		20	U	119		5000
Manganese		130		5420		7180		52.3		53.6		9470		2810		7390		1750		
Mercury		0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	0.2	U	200
Nickel		81.1		780		48.9		20	U	20	U	221		35.1	B	277		254		
Zinc		1730		662000		7570		2140		2170		6190		7790		4450		4890		
Soil Nature		red shale and slag		slag		org. soil in slag		shaley sand in slag				slag		slag		recent alluvium		slag		
Grain Size		clayey sand some gravel		sandy gravel		sandy silty clay		silty sand				silty sandy gravel		silty sandy gravel		gravelly sand		gravelly silty sand		

Notes:
Concentrations are given in ug/l.
U indicates that constituent concentration was below the indicated detection limit.
B indicates that constituent concentration was between the detection limit and the contract required detection limit.
DP indicates a duplicated sample.
Regulatory limits per IHWMR 721.24.

Table 5.6 (Continued) Phase II Site Investigation
Carus Chemical Company
Soil TCLP Metals Analysis

Parameter	Boring Hole	P-19	P-19	P-21	P-21	P-21	P-21	P-22	P-22	Reg.
	Depth (ft)	20	42	2.5	21	41	60	41	106	Limit
Barium		158 B	131 B	54.3 B	68.9 B	101 B	108 B	74.6 B	616	10000
Cadmium		62	1100	39.9	27.1	67.1	290	20.7	8	1000
Chromium		9.7 B	5 U	5 U	5.4 B	5 U	8.9 B	9.4 B	5 U	5000
Iron		423	209	50 U	50 U	50 U	1010	1530	50 U	
Lead		20 U	20 U	2430	48.4	510	390	206	20 U	5000
Manganese		174	323	61.7	647	670	779	69	4890	
Mercury		0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	200
Nickel		29.1 B	1100	25.3 B	94.1	20 U	20 U	20 U	20 U	
Zinc		107000	9080	184000	4560	1100	6390	6180	1690	
Soil Nature		clay and slag	slag	topsoil	slag	slag	slag	slag	alluvium	
Grain Size		gravel to sand	grayish red	sandy clayey silt	gravelly sand	gravelly sand	gravelly sand	gravelly sand	clayey gravel	

Notes:
Concentrations are given in ug/l.
U indicates that constituent concentration was below the indicated detection limit.
B indicates that constituent concentration was between the detection limit and the contract required detection limit.
Regulatory limits per IHWMR 721.24.

Table 5.7 IEPA SSI Ground-Water Total Metals Analysis

SAMPLING POINT	REG[1] (mg/l)	BACKGROUND G112 (mg/l)	G101 (mg/l)	G103 (mg/l)	G106 (mg/l)
		11/20/91	11/20/91	11/20/91	11/20/91
PARAMETER					
Volatiles					
Acetone		0.01	-	-	-
Semi-Volatiles					
Fluoranthene		0.01	-	-	-
Pyrene		0.01	-	-	-
Pesticides					
Arochlor 1254	0.0025	0.001	-	-	-
Arochlor 1260	0.0025	0.001	-	-	-
Tentatively Identified Compounds					
Ethane,1,1,2-trichloro-1,2		-	-	-	-
Hexanoic Acid		-	-	-	-
Inorganics					
Aluminum		3.4	48.3	123.0	55.0
Arsenic	0.2	0.003	0.0211	-	-
Barium	2.0*	0.166	-	2.53	-
Beryllium		0.001	-	0.013	0.005
Cadmium	0.05	0.002	0.037	0.019	0.035
Calcium		0.2	-	655.0	654.0
Chromium	1.0	0.007	0.057	0.248	0.121
Cobalt	1.0	0.01	0.047	0.0711	0.074
Copper	0.65*	0.027	0.100	0.249	0.385
Iron	5.0*	6.11	33.8	208.0	84.6
Lead	0.1	0.009	0.448	0.179	0.109
Magnesium		61.0	-	195.0	-
Manganese	10*	0.26	3.7	14.40	9.11
Mercury	0.01	0.0002	0.0016	-	-
Nickel	2.0*	0.024	0.075	0.207	0.116
Potassium		8.36	33.8	46.10	133.0
Silver		-	-	-	-
Sodium		165.0	-	2002.0	215.0
Vanadium		0.012	0.062	0.265	0.092
Zinc	10*	0.022	3.32	3.640	17.10
Sulfate	400*	174.0	1060.0	1680.0	2080.0
Selenium	0.05*	NT	NT	NT	NT

[1] IEPA Ground Water Quality Standards (Class II), Part 620, Subpart D
[2] NT = Not Tested
- indicates below detection limit.
* indicates standard not applicable to ground water within fill material.

Table 5.8 PSI Ground-Water Total Metals Analysis

SAMPLING POINT	G101 (mg/l)	G103 (mg/l)	G106 (mg/l)	MW-1 (mg/l)	MW-2 (mg/l)
	10/09/92	10/09/92	10/09/92	10/09/92	10/09/92
PARAMETER					
Arsenic	0.003	0.003	0.006	0.003	0.019
Barium	<0.10	2.18	0.32	0.350	0.48
Cadmium	<0.005	0.012	0.046	0.015	0.011
Chromium	0.013	0.163	0.065	0.022	0.079
Lead	0.038	0.045	0.13	0.022	0.11
Mercury	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Silver	<0.010	0.033	0.055	0.018	0.038
Selenium	<0.002	<0.002	<0.002	0.002	0.002

Table 5.9
Phase I Ground-Water Metals Analysis (Nov. 93)

	Class II STD	G-04 (ug/L)	G-02 (ug/L)	G-05 (ug/L)	G-101 (ug/L)	G-103 (ug/L)	G-106 (ug/L)	MW-1 (ug/L)	MW-2 (ug/L)	NPDES (ug/L)	Cool W. (ug/L)	Blank (ug/L)
Aluminum, total			996	6310	<100	<100	<100	3740	25800	108	<100	<100
Aluminum, diss.			<100	<100	<100	<100	<100	479	780	100		<100
Antimony, total			<25	<25	<25	<25	<25	<25	<25	<25	<25	<25
Antimony, diss.			<25	<25	<25	<25	<25	<25	<25	<25		<25
Arsenic, total	200	6.8	<1.0	5.5	1.2	1	2.5	9	22.1	9.6	2.3	<1.0
Arsenic, diss.		2.9	1.3	2.6	2	3	7.6	5.6	7.1	3.6		<1.0
Barium, total	2000*	139	55.2	134	18.2	23.7	17.2	85.1	1080	172	210	<5.0
Barium, diss.		72.3	39.8	47.8	17.8	18.6	22.3	41.7	27.8	164		28.1
Beryllium, total			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	3.7	<1.0	<1.0	<1.0
Beryllium, diss.			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0		<1.0
Cadmium, total	50	<4.0	<4.0	25.5	<4.0	<4.0	5.6	28.9	51	<4.0	<4.0	<4.0
Cadmium, diss.		<4.0	<4.0	5.3	<4.0	<4.0	<4.0	12.1	<4.0	<4.0		<4.0
Calcium, total			437000	260000	204000	292000	578000	603000	706000	108000	116000	<100
Calcium, diss.			461000	274000	226000	326000	596000	647000	432000	115000		<100
Chromium, total	1000	<5.0	5.7	7.7	<5.0	<5.0	<5.0	<5.0	76.7	10.9	<5.0	<5.0
Chromium, diss.		<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Cobalt, total	1000		19	22.4	<5.0	<5.0	12.4	8.2	101	<5.0	5.3	<5.0
Cobalt, diss.			20.3	13.9	<5.0	<5.0	16.1	8.2	29.6	<5.0		6.8
Copper, total	650*		31.1	94	13.4	<5.0	<5.0	21.7	312	6.6	8.2	<5.0
Copper, diss.			77	<5.0	9.9	<5.0	<5.0	<5.0	7.4	<5.0		<5.0
Cyanide, total	600		<6.2	<5.0	<6.2	<5.0	<5.0	<6.2	<5.0	43.4	<6.2	<6.2
Iron, total	5000*		838	11200	<75.0	<75.0	3050	7280	137000	300	694	<75.0
Iron. diss.			<75.0	597	<75.0	<75.0	3210	1160	3910	<75.0		<75.0
Lead, total	100	20.4	5.8	2180	11	<5.0	9.6	31.3	303	15.8	<1.0	<1.0

Notes:
Class II STD = Illinois ground-water quality standard for Class II ground water, IAC 620, Subpart D (ug/L).
* indicates Class II standards not applicable according to IAC 620.420 (a) (3).
Cool Water = Sample of cooling water derived from city of LaSalle municipal water supply.
Blank = Equipment blank.
NPDES = Surface water sample collected near NPDES discharge pipe.

Table 5.9 (Continued)
Phase I Ground-Water Metals Analysis (Nov. 93)

	Class II STD	G-04 (ug/L)	G-02 (ug/L)	G-05 (ug/L)	G-101 (ug/L)	G-103 (ug/L)	G-106 (ug/L)	MW-1 (ug/L)	MW-2 (ug/L)	NPDES (ug/L)	Cool W. (ug/L)	Blank (ug/L)
Lead, diss.		3.9	2	291	11.3	3.2	<5.2	10.8	24.5	2		<1.0
Magnesium, total			103000	132000	111000	136000	64200	48400	140000	38700	37700	<100
Magnesium, diss.			95900	138000	119000	146000	68000	49800	126000	43900		<100
Manganese, total	10000*		3830	3240	26.3	433	6240	6580	16900	450	618	<5.0
Manganese, diss.			4370	3150	23.7	460	6550	7700	4020	396		<5.0
Mercury, total	10	<0.2	<0.2	12.9	<0.2	<0.2	<0.2	<0.2	2.1	<0.2	<0.2	<0.2
Mercury, diss.		<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2		<0.2
Nickel, total	2000*		41.3	38	13.6	12	22.2	30.1	212	<10.0	<10.0	<10.0
Nickel, diss.			38.7	13.6	11	10.8	22.5	14.9	14.7	<10.0		<10.0
Potassium, total			12800	77300	8160	2420	80200	96700	108000	10300	2540	<2000
Potassium, diss.			10600	77300	8640	2550	83300	102000	108000	6970		<2000
Selenium, total	50*	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<1.0	<1.0
Selenium, diss.		<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0		<1.0
Silver, total			<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Silver, diss.			<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0		<5.0
Sodium, total			115000	151000	215000	125000	12900	114000	227000	94700	34900	<900
Sodium, diss.			104000	153000	215000	124000	132000	117000	228000	114000		<900
Sulfate	400000*		1300000	885000	610000	908000	1520000	1480000	1460000	226000	114000	<1000
Sulfide			<1000	<1000	<1000	<1000	<1000	<1000	2300	20900	<1000	<1000
Thallium, total			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	1.3	<1.0	<1.0	<1.0
Thallium, diss.			<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Vanadium, total			<5.0	15	<5.0	<5.0	<5.0	15.9	155	<1.0	<5.0	<5.0
Vanadium, diss.			<5.0	<5.0	<5.0	<5.0	<5.0	6.8	<5.0	<1.0		6.3
Zinc, total	10000*		305	6400	229	175	10200	7200	26400	41.5	83.1	<5.0
Zinc, dissolved			538	3280	216	180	11000	5090	2270	18.1		<5.0

Notes:

Class II STD = Illinois ground-water quality standard for Class II ground water, IAC 620, Subpart D (ug/L).

* indicates Class II standards not applicable according to IAC 620.420 (a) (3).

Cool W. = Sample of cooling water derived from city of LaSalle municipal water supply.

Blank = Equipment blank.

NPDES = Surface water sample collected near NPDES discharge pipe.

Table 5.10. Phase I Site Investigation
Carus Chemical Company
Ground-Water Organic Analyses

Parameter	Units	Ground-Water Standards	Sample Identification		
		CLASS II[1]	G-04 (Nov 93) Total	G-02 (Nov 93) Total	NPDES Outfall (Nov 93) Total
Benzene	ug/L	25	550	<1	na
Toluene	ug/L	2,500	360	<1	na
Ethylbenzene	ug/L	1,000	390	<1	na
Xylenes	ug/L	10,000	1,200	<1	na
Naphthalene	ug/L	—	45	<10	<10
Acenaphthylene	ug/L	—	<10	<10	<10
Acenaphthene	ug/L	—	<18	<10	<10
Fluorene	ug/L	—	<2.1	<10	<10
Phenanthrene	ug/L	—	<6.4	<10	<10
Anthracene	ug/L	—	<6.6	<10	<10
Fluoranthene	ug/L	—	1	<10	<10
Pyrene	ug/L	—	<2.7	<10	<10
Benzo(a)anthracene	ug/L	—	<1.5	<10	<10
Chrysene	ug/L	—	2.4	<10	<10
Benzo(b)fluoranthene	ug/L	—	<0.18	<10	<10
Benzo(k)fluoranthene	ug/L	—	<0.17	<10	<10
Benzo(a)pyrene	ug/L	—	<0.23	<10	<10
Dibenzo(a,h)anthracene	ug/L	—	<0.30	<10	<10
Benzo(g,h,i)perylene	ug/L	—	<0.76	<10	<10
Indeno(1,2,3-cd)pyrene	ug/L	—	<0.43	<10	<10

Notes:
1 Class II denotes Illinois Ground Water Quality Standards for Class II Ground Water, IAC 620, Subpart D.
— denotes no standard exists.
na denotes not analyzed.

TABLE 5.11 PHASE II SITE INVESTIGATION
CARUS CHEMICAL COMPANY
GROUND-WATER ANALYSES

Parameter	Piezometer	P-6		P-15A		EB-1		EB-2		P-15		P-18		P-18		P-19		P-1		Class II
	Date	Nov-94		Nov-94		Nov-94		Nov-94		Nov-94		Nov-94		Nov-94		Nov-94		Nov-94		Standard
	TotalDiss	Total		Total		Total		Total		Total		Total		Total		Total		Total		
Barium		47.8	B	91.5	B	5.0	U	5.0	U	41.5	B	15.0	B	15.0	B	23.2	B	6.8	B	2000
Cadmium		3.0	B	3.0	B	3.0	U	3.0	U	3.0	U	**562**		**552**		**72.0**		**2220**		50
Chromium		5.0	U	5.0	U	5.0	U	5.0	U	5.0	U	5.0	U	5.0	U	5.0	U	6.6	B	1000
Iron		1290		163		104		136		190		**17300**		**17100**		130		1480		5000
Lead		5.0	U	67.4		1.0	U	1.0	U	10.4	B	5.0	U	5.0	U	5.0	U	5.0	U	100
Manganese		**25300**		2530		123		157		3280		**11500**		**11400**		1210		**12400**		10000
Mercury		0.20	U	0.20	U	0.20	U	0.20	U	0.20	U	0.24		0.20	U	0.20	U	0.25		10.00
Nickel		31.9	B	45.9		20.0	U	20.0	U	20.0	U	485		480		46.0		1090		2000
Zinc		921		5260		5.0	U	5.0	U	517		**382000**		**393000**		6460		**831000**		10000
Cyanide		5.0	U	6.2	U	6.2	U	6.2	U	5.0	U	5.4		NA		6.1		5.0	U	600
Bicarbonate		453000		396000		4960	U	4960	U	466000		124000		NA		332000		4960		
Carbonate		331		526		0.10	U	0.10	U	390		36.0		NA		291		0.0	U	
Sulfate		**1890000**		157000		2000	U	2000	U	**502000**		**2450000**		NA		**1300000**		**4440000**		400000
Sulfide		1000	U	1000	U	1000	U	1000	U	1000	U	1000	U	NA		1000	U	1000	U	
TSS		252000		8470		6670	U	6670	U	6670	U	28300		NA		7870		16100		

Notes:

1. Concentration units given in ug/l.
2. U indicates that constituent concentration was below the indicated detection limit.
3. B indicates that constituent concentration was between the detection limit and the contract required detection limit.
4. NA indicates that sample was not analyzed for that constituent.
5. TSS: Total Suspended Solids.
6. EB-1 and EB-2 indicate analyses of deionized water (Carus Lab.) and deionized water after material washing respectively.
7. Bold/highlighting indicates exceedance of Class II Ground Water Standard (IAC 620, subpart D).

TABLE 5.11 CONTINUED
PHASE II SITE INVESTIGATION
CARUS CHEMICAL COMPANY
GROUND-WATER ANALYSES

Parameter	Piezometer	G-04		P-9		P-7		MW-1DP		MW-1		MW-2		P-17		Class II
	Date	Nov-94		Nov-94		Nov-94		Nov-94		Nov-94		Nov-94		Nov-94		Standard
	TotalDiss	Total		Total		Total		Total		Total		Total		Total		
Barium		16.1	B	24.3	B	46.8	B	24.2	B	24.3	B	33.8	B	24.7	B	20000
Cadmium		3.0	U	5.2		3.0	U	12.5		13.9		3.0	U	3.0	U	50
Chromium		5.0	U	5.0	U	5.0	U	5.0	U	5.0	U	5.0	U	5.0	U	1000
Iron		**12600**		50.0	U	**14700**		4450		3910		**5900**		**5380**		5000
Lead		5.0	U	5.0	U	10.9	B	5.0	U	5.0	U	5.0	U	11.4	B	100
Manganese		4700		629		**20700**		**10800**		9800		2650		2020		10000
Mercury		0.20	U	0.48		0.20	U	0.20	U	0.20	U	0.20	U	0.20	U	10
Nickel		20.0	U	20.0	U	31.0	B	29.0	B	47.1		37.7	B	90.7		2000
Zinc		42.3		941		2670		8280		8370		1130		8840		10000
Cyanide		5.0	U	5.0	U	5.0	U	6.2	U	8.5		6.7		5.0	U	600
Bicarbonate		279000		413000		384000		229000	U	229000		203000		223000		
Carbonate		204		224		249		175	U	206		170		276		
Sulfate		**2990000**		**1510000**		**1890000**		**1640000**		**1590000**		**1170000**		**1350000**		400000
Sulfide		1000	U	1000	U	1000	U	1000	U	1000	U	1000	U	1000	U	
TSS		NA		NA		NA		NA		NA		29700		27700		

Notes:

1. Concentration units given in ug/l.
2. U indicates that constituent concentration was below the indicated detection limit.
3. B indicates that constituent concentration was between the detection limit and the contract required detection limit.
4. NA indicates that sample was not analyzed for that constituent.
5. TSS: Total Suspended Solids.
6. DP indicates a duplicated sample.
7. Bold/highlighting indicates exceedance of Class II Ground Water Standard (IAC 620, Subpart D).

TABLE 5.12 PHASE II SITE INVESTIGATION
CARUS CHEMICAL COMPANY
GROUND-WATER HYDROCARBON ANALYSES

Parameter	Sample	P-6		G-04		Class II
	Date	Nov-94		Nov-94		Ground Water
	Analyses	VOC		VOC		Standard
Benzene		5	U	**870**		25
Toluene		5	U	250		2500
Ethylbenzene		5	U	950		1000
Xylene (total)		5	U	1400		10000
Naphtalene		10	U	1.3	J	
Acenaphthalene		10	U	10	U	
Acenaphtene		18	U	18	U	
Fluorene		2.1	U	2.1	U	
Phenanthrene		6.4	U	6.4	U	
Anthracene		6.6	U	6.6	U	
Fluoranthene		2.1	U	2.1	U	
Pyrene		2.7	U	2.7	U	
Benzo(a)anthracene		0.13	U	0.13	U	
Chrysene		1.5	U	1.5	U	
Benzo(b)fluoranthene		0.18	U	0.18	U	
Benzo(k)fluoranthene		0.17	U	0.17	U	
Benzo(a)pyrene		0.23	U	0.23	U	
Dibenzo(a,h)anthracene		0.30	U	0.30	U	
Benzo(g,h,i)perylene		0.76	U	0.76	U	
Indeno(1,2,3-cd)pyrene		0.43	U	0.43	U	

Notes:

1. Concentration units given in ug/l.
2. U indicates that constituent concentration was below the indicated detection limit.
3. J indicates estimated concentration.
4. Bold/highlighting indicates exceedance of Class II Ground Water Standard.

Table 5.13. River Sediments Chemical Analyses (Previous Investigations)

SAMPLING POINT	REGULATORY LIMIT[1] (mg/l)	IEPA SSI BACKGROUND X208 11/20/91	PSI BACKGROUND S/S3 10/3/92	IEPA SSI X201 11/21/91	IEPA SSI X202 11/21/91	IEPA SSI X203 11/21/91	IEPA SSI X204 11/21/91	PSI S/S2 10/3/92	PSI S/S1 10/3/92
PARAMETER									
Inorganics (mg/kg)[3]									
Aluminum		3,430	NT	-	20,000	-	-	NT	NT
Arsenic	5.0	4.5	0.043	-	-	-	-	0.036	0.038
Barium	100.0	33.5	0.65	-	157	111	226	1.45	0.45
Beryllium		0.5	NT	-	1.5	2.3	-	NT	NT
Cadmium	1.0	1.3	0.021	36.8	22.8	15.3	5.1	<0.005	0.085
Chromium	5.0	6.0	0.024	19.9	39.3	37.5	21.3	0.022	0.029
Cobalt		5.5	NT	-	18.6	-	-	NT	NT
Copper		7.7	NT	102	46.3	186	49.1	NT	NT
Iron		8,600	NT	-	-	46,000	-	NT	NT
Lead	5.0	7.6	<0.10	594	1,050	733	262	0.13	0.67
Manganese		520	NT	-	-	1,580	-	NT	NT
Mercury	0.2	0.074	<0.002	0.53	-	0.35	-	0.002	0.002
Nickel		7.4	NT	-	28.9	85.4	-	NT	NT
Potassium		733	NT	-	3,350	-	-	NT	NT
Sodium		171	NT	-	-	-	-	NT	NT
Vanadium		8.7	NT	-	43.9	68.8	-	NT	NT
Zinc		60.2	NT	6,500	4,630	6,290	1,570	NT	NT
Cyanide		0.26	<0.25	-	1.3	-	-	<0.25	<0.25
Sulfide		1.0	NT	-	16	-	-	NT	NT
Selenium	1.0	NT	<0.002	NT	NT	NT	NT	<0.002	<0.002
Silver	5.0	NT	0.044	NT	NT	NT	NT	0.068	<0.010

1 Regulatory Limits per Illinois Hazardous Waste Management Regulation § 721.24
2 NT = Not Tested
3 S/S1, S/S2, and S/S3 listed as mg/l in TCLP waste extract
- indicates below detection limit

TABLE 5.14 PHASE II SITE INVESTIGATION
CARUS CHEMICAL COMPANY
RIVER-WATER ANALYSES

Parameter		Quarry Bridge		Section Line		Section Line DP		5th St. Bridge		Standards	
	River Section	Quarry Bridge		Section Line		Section Line DP		5th St. Bridge		Standards	
	Date	Nov-94		Nov-94		Nov-94		Nov-94		Surface Water	Surface Water
	Analyses	Total		Total		Total		Total		Acute Standard	Chronic Standard
Barium		98.4	B	113	B	113	B	115	B	5000	5000
Cadmium		3.0	U	3.0	U	3.0	U	3.0	U	50	11.5
Chromium		5.0	U	5.0	U	5.0	U	5.0	U	20000	2000
Iron		**1400**		**3180**		**3540**		**1930**		1000	1000
Lead		2.8	B	7.6		2.2	B	2.0	B	100	100
Manganese		187		**1240**		**1770**		106		1000	1000
Mercury		0.20		0.20	U	0.20	U	0.22		0.50	0.50
Nickel		20.0	U	20.0	U	28.4	B	20.0	U	1000	1000
Zinc		27.6		88.7		116		96.3		1000	1000
Cyanide		**10.0**		**8.2**		**10.0**		**6.2**	U	22	5.2
Bicarbonate		251000		246000		251000		246000			
Carbonate		3040		3190		3330		3050			
Sulfate		37100		38600		39100		40400		500000	500000
Sulfide		1000	U	1000	U	1000	U	1000	U		
TSS		29600		65800		72400		102000			

Notes:

1. Concentration units given in ug/l.
2. U indicates that constituent concentration was below the indicated detection limit.
3. B indicates that constituent concentration was between the detection limit and the contract required detection limit.
4. NA indicates that sample was not analyzed for that constituent.
5. TSS: Total Suspended Solids.
6. DP indicates a duplicated sample.
7. Bold/highlighting indicates exceedance of chronic or acute surface-water standards.
8. General Use water quality standards are from Section 302 of 35 IAC.

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TABLE 5.15 PHASE II SITE INVESTIGATION
CARUS CHEMICAL COMPANY
RIVER SEDIMENT TOTAL AND TCLP ANALYSES

Parameter	River Sec.	Qrry.Bridge-07B		Qrry.Bridge-07B		Sect. Line		Sect. Line		5th St. -05B		5th St. -05B	
	Date	Nov-94		Nov-94		Nov-94		Nov-94		Nov-94		Nov-94	
	Anal.Type	Total		TCLP		Total		TCLP		Total		TCLP	
Barium		101		830		35.3	B	682		42.2	B	821	
Cadmium		2.4		5.8		20.5		5.0		4.3		33.0	
Chromium		13.1		5.0	U	7.1		5.0	U	4.6		5.0	U
Iron		16100		50.0	U	41500		50.0	U	9990		50.0	U
Lead		101		20.0	U	55.8		25.5	U	31.2		32.4	
Manganese		584		1560		662		4290		313		5010	
Mercury		0.35		0.20	U	0.12	U	0.20	U	0.13	U	0.20	U
Nickel		24.0		20.0	U	25.4		28.2	B	12.8		40.4	
Zinc		175		349		1400		1360		598		6810	

Notes:

1. Concentration units in mg/kg for total soil and ug/l for TCLP.
2. U indicates that constituent concentration was below the indicated detection limit.
3. B indicates that constituent concentration was between the detection limit and the contract required detection limit.

Table 5.16. Pond Sediments Chemical Analyses (IEPA SSI)

SAMPLING POINT	X205 11/21/91	X206
PARAMETER		
Volatiles (μg/kg)		
Methylene Chloride	-	-
Acetone	410	220
Semivolatiles (μg/kg)		
Phenanthrene	-	1,400
Fluoranthene	-	2,300
Pyrene	-	2,300
Benzo(a)anthracene	-	1,100
Chrysene	-	1,100
Bis(2-Ethylhexyl) phthalate	460	580
Benzo(b)fluoranthene	-	1,600
Pesticides (μg/kg)		
Arochlor 1254	-	-
Arochlor 1260	-	1,100
Tentatively Identified Compounds (μg/kg)		
Ethane,1,1,2-trichloro-1,2	-	-
Inorganics (mg/kg)[1]		
Aluminum	-	-
Arsenic	31.5	37.7
Barium	361	867
Beryllium	-	-
Cadmium	-	10.3
Chromium	57.1	41.9
Cobalt	-	18.4
Copper	185	383
Iron	-	-
Lead	69.8	326
Manganese	17,000	28,900
Mercury	0.27	0.29
Nickel	50.4	91
Potassium	-	-
Sodium	808	842
Vanadium	57.5	49.6
Zinc	609	2,790
Cyanide	-	-
Sulfide	140	-
Selenium	NT	NT
Silver	NT	NT

TABLE 5.17 PHASE II SITE INVESTIGATION
CARUS CHEMICAL COMPANY
HOLDING POND SEDIMENT TOTAL METALS ANALYSIS

Parameter	Location	Pond Line 1		Pond Line 2		Pond Line 2 DP		Pond Line 4	
	Depth (ft)	composite		composite		composite		composite	
Barium		2020		6770		7310		3620	
Cadmium		8.3		4.9		4.5		5.2	
Chromium		130		277		255		280	
Iron		33800		127000		109000		193000	
Lead		133		141		148		130	
Manganese		46700		103000		76200		155000	
Mercury		0.81		1.4		1.9		0.97	
Nickel		174		448		495		737	
Zinc		1620		513		595		551	
Cyanide		1.1	U	1.2	U	1.3	U	1.5	U
Bicarbonate		638		538		539		289	
Carbonate		51.1		47.2		49.5		4.9	
Sulfate		719		967		1240		25800	
Sulfide		142	U	137	U	155	U	177	U
Soil Nature		organic silt		organic silt		organic silt		organic silt	
Grain Size		silt		silt		silt		silt	
Dyr/Moist/Wet		wet		wet		wet		wet	

Notes:

1. Concentration units are given in mg/kg.
2. U indicates that constituent concentration was below the indicated detection limit.
3. Comp indicates a composite sample from several depth and location in the socft sediment on a same section.
4. DP indicates a duplicate sample.

TABLE 5.18 PHASE II SITE INVESTIGATION
CARUS CHEMICAL COMPANY
HOLDING POND SEDIMENT TCLP ANALYSES

Parameter	Location	Pond Line 1		Pond Line 2		Pond Line 2 DP		Pond Line 4	
	Depth (ft)								
Barium		1560		646		755		132	B
Cadmium		5.4		3.0	U	3.0	U	3.0	U
Chromium		5.0	U	9.2	B	8.0	B	23.0	
Iron		50.0	U	50.0	U	56.2	B	50.0	U
Lead		21.2		20.0	U	20.0	U	20.0	U
Manganese		1750		147000		125000		454000	
Mercury		0.20	U	0.20	U	0.20	U	0.20	U
Nickel		238		192		163		328	
Zinc		490		121		89.7		87.2	
Soil Nature		organic silt		organic silt		organic silt		organic silt	
Grain Size		silt		silt		silt		silt	
Dyr/Moist/Wet		wet		wet		wet		wet	

Notes:

1. Concentration units are given in mg/kg.
2. U indicates that constituent concentration was below the indicated detection limit.
3. Comp indicates a composite sample from several depth and location in the socft sediment on a same section.
4. B indicates that constitutent concentration was between the detection limit and the contract required detection limit.
5. DP indicates a duplicate sample.

TABLE 5.19 PHASE II SITE INVESTIGATION
CARUS CHEMICAL COMPANY
HOLDING POND SEDIMENT PAH ANALYSIS

Parameter	Sample	Pond Line 1		Pond Line 2		Pond Line 2 DP		Pond Line 4	
	Date	Nov-94		Nov-94		Nov-94		Nov-94	
	Analyses	VOC		VOC		VOC		VOC	
Naphtalene		10	U	10	U	10	U	10	U
Acenaphtylene		10	U	10	U	10	U	10	U
Acenaphtene		18	U	18	U	18	U	18	U
Fluorene		2.1	U	2.1	U	2.1	U	2.1	U
Phenanthrene		6.4	U	6.4	U	6.4	U	6.4	U
Anthracene		6.6	U	6.6	U	6.6	U	6.6	U
Fluoranthene		2.1	U	2.1	U	2.1	U	2.1	U
Pyrene		2.7	U	2.7	U	2.7	U	2.7	U
Benzo(a)anthracene		0.13	U	0.13	U	0.13	U	0.13	U
Chrysene		1.5	U	1.5	U	1.5	U	1.5	U
Benzo(b)fluoranthene		0.18	U	0.18	U	0.18	U	0.18	U
Benzo(k)fluoranthene		0.17	U	0.17	U	0.17	U	0.17	U
Benzo(a)pyrene		0.23	U	0.23	U	0.23	U	0.23	U
Dibenzo(a,h)anthracene		0.30	U	0.30	U	0.30	U	0.30	U
Benzo(g,h,i)perylene		0.76	U	0.76	U	0.8776	U	0.76	U
Ideno(1,2,3-cd)pyrene)		0.43	U	0.43	U	0.43	U	0.43	U

Notes:

1. Concentration units are given in ug/l
2. U indicates that constituent concentration was below the indicated detection limit.
3. DP indicates a duplicate sample.

DISCUSSION

6. DISCUSSION

6.1 Overview

The Phase II Investigation defined in the Phase II Work Plan was designed to evaluate the following issues:

- the mechanism of ground-water flow from the upland flow system in the Phase I Area into the lowland flow system in the Phase II Area;
- the extent to which water from the Little Vermilion River contacts the slag along the river bank;
- whether or not a significant thickness of alluvium is present beneath the slag, and if so, the transmissivity of the alluvium;
- the flow rate in the Little Vermilion River system at the property boundary;
- the concentration of chemical constituents in ground water and surface water at the downstream property boundary, as compared to the background concentrations of chemical constituents at the upstream and upgradient property boundary;
- the extent of chemical constituents in the ground water in the Phase II Area; and
- the potential source of chemical constituents, including:
  - the slag deposits,
  - holding pond sediments,
  - off-site sources, and
  - natural rocks and soils.

Moreover, as discussed in Section 1.2 of this report, the four main objectives of the Phase II Investigation are:

- to characterize the nature and extent of suspected "hazardous substances", as defined in Section 101(14) of CERCLA, and as previously defined by the IEPA;

- to determine the relationship between various industrial deposits (e.g., slag) and suspected "hazardous substances";

- to determine the relationship between the industrial deposits and water resources for the area; and

- to perform all work in accordance with applicable requirements and standards established by the USEPA and the IEPA.

The findings related to these issues and objectives are described in the remainder of Section 6.

6.2 Mechanism of Ground-Water Flow

During the Preliminary Investigation and the Phase I and II Investigations, 52 borings were advanced to evaluate the stratigraphy of the site. The geology is fully defined, as discussed in Section 4 and as presented in Drawings 2 through 9 of this report. The mechanism of ground-water flow is discussed in Section 4.4 and shown in Drawing 10. The primary findings of the investigation related to the mechanism of ground-water flow are summarized below:

- The Carus Chemical Company site is underlain by a multicomponent shallow flow system which consists of: (i) the gully-fill system; (ii) the holding pond system; (iii) the alluvial system; and (iv) the upland-soil system, as defined in Sections 4.4.2 through 4.4.5, respectively.

- Ground-water flow at the site is dominated by the alluvial flow system, which consists of the Little Vermilion River and ground water within the alluvium.

- The upland-soil system (located in the Phase I Area) flows into the gully-fill system. Water from the gully-fill system discharges toward the Little Vermilion River, into the alluvial flow system. Ground water from these two flow systems (i.e., the upland flow and gully-fill systems) is believed to originate primarily from fugitive losses of non-contact cooling water from the plant sewer and associated piping and precipitation.

- The holding pond forms a leaky perched flow system; however, leakage from the holding pond is minimal and contributes negligible water to the alluvial flow system. Direct discharge from the holding pond to the alluvial flow system occurs via the NPDES discharge point. Periodic monitoring is performed in accordance with permit requirements.

- A confining layer exists underneath the site and corresponds to the top of the Pennsylvanian bedrock or, where present, the Pleistocene deposits (Drawing 9). This lower confining unit is sufficient to prevent appreciable migration to deeper aquifers, as evidenced by the lithologic character of the Pennsylvanian system (Section 4.3.2), and the existence of a coal mine within the Pennsylvanian system that was reportedly dry during its operational life..

The significance of this finding is that shallow ground water underlying the site is isolated from deeper aquifers. Rather, all shallow ground water flows into the alluvial flow system.

6.3 Contact of the Little Vermilion River with Slag

As shown in Drawings 3, and 6 through 8, slag is in contact with the Little Vermilion River along approximately 80 percent of the river bank. Along the southeastern portion of the site (the remaining 20 percent) slag is present, but is mixed with alluvium (Drawing 6, Cross Section K) (i.e., referred to within the report as the "*distal slag alluvium*").

6.4 Presence of Alluvium beneath the Slag

During the Phase II Investigation, alluvium was found underlying the slag in borings P-15, P-17, P-18, and P-22. Alluvium was observed to be up to 30 ft (9.1 m) in thickness and is in direct hydraulic connection with the Little Vermilion River. This finding is significant in that along most of the length of the Phase II Area, the alluvium has the capacity to account for a relatively high proportion of the flow in the alluvial flow system, compared to the flow in the Little Vermilion River. At the southern end of the Phase II Area (near the Fifth Street Bridge); however, the thickness, width, and hydraulic conductivity of the alluvium appears to decrease. These factors reduce the flow capacity of the alluvium and force water to discharge up into the Little Vermilion River.

6.5 Flow Rate in the Little Vermilion River at the Property Boundary

The flow rate of the Little Vermilion River was measured at four locations on 7 October 1994. The measured values provided instantaneous values for general information purposes (e.g., to develop a water budget).

6.6 Concentration of Constituents in Ground Water and Surface Water - Downgradient of the Site

An attempt was made to locate a monitoring well/piezometer at the downgradient property boundary; however, this was not feasible because of safety and accessibility reasons. In lieu of evaluating ground water at the downstream property boundary, the chemical composition of river water was measured downgradient of the site (i.e., at the Fifth Street Bridge). As discussed in Section 5.4, river water quality downstream of the site is better than river water quality upstream of the site. This is likely due to the dilution of river water by discharge of water from the Carus Chemical Company property to the Little Vermilion River (Section 5.4).

6.7 Concentration of Constituents in Ground Water and Surface Water - Upgradient of the Site

Surface water was evaluated at two locations in the Little Vermilion River upgradient of the Carus Chemical Company Phase II Area (Section 5.4.3). As discussed in Section 6.6, the river water quality downstream of the site is better than the river quality upstream of the site. Piezometer P-1 is located at the upgradient property boundary of the Carus site based on the ground-water flow conditions of the alluvial flow system. The ground-water quality measured in the sample obtained from this piezometer indicates that ground water flowing into the Carus site from the former M&H Zinc Company exceeds the Class II ground-water standards for cadmium (2.2 mg/L), manganese (12.4 mg/L), zinc (831.0 mg/L), and sulfate (4,440.0 mg/L). Cadmium, zinc, and sulfate concentrations are higher in upgradient piezometer P-1 than in any other monitoring well or piezometer. Moreover, the zinc concentration is more than twice as high as any other monitoring well or piezometer.

6.8 Extent of Chemical Constituents in the Phase II Area

The extent of chemical constituents in the Phase II Area is shown on Drawings 11 through 13. The following points summarize ground-water quality at the site:

- Sulfate exceeds the Class II ground-water quality standard throughout the site.
- Iron exceeds the Class II ground-water quality standards in piezometers P-6 and P-7, which are screened in till and shale, respectively. Higher concentrations of iron were also observed adjacent to the holding pond relative to the remainder of the site.

- Manganese is predominant throughout the site, with the highest concentrations measured in piezometers P-6 and P-7, which are screened in natural geologic materials.

- Iron, manganese, and sulfate were all measured above Class II ground-water quality standards in monitoring wells screened within natural geologic materials.

- Cadmium and zinc concentrations exceeded the Class II ground-water quality standards in upgradient piezometer P-1 and in piezometer P-18, which are both screened in the alluvial flow system. Both of these piezometers are screened at least partially in the slag; therefore, the Class II standards for zinc do not apply.

- Cadmium, zinc, and sulfate concentrations were higher in upgradient piezometer P-1 than in any other monitoring well or piezometer.

- A small isolated area of the site located at the northeast corner of the main plant area has believed to have been impacted by an above ground storage tank that is located on the former M&H Zinc Company property. Benzene and other organics were detected. Spillage and overflow of the dike are the likely causes of the impacts by organic constituents. Heavy rainfall conditions cause overflow of the dike surrounding the tank and infiltration of the surface water occurs in the sand and gravel lens, which is shown on Drawing 10.

6.9 Potential Source of Chemical Constituents

The source of chemical constituents measured at the site, as evidenced by historical data and information, and the findings from the Phase II Investigation may be as follows:

- The slag deposits appear to be a contributing factor to the zinc and cadmium concentrations observed at the site.

- Natural rocks and soils appear to be a contributing factor to the iron, manganese, and sulfate observed at the site.

- The sediments in the holding pond may be a contributing source of the iron observed in the ground water obtained from the monitoring wells and piezometers located adjacent to the holding pond. The higher concentrations of iron relative to those measured in other portions of the site could result from remobilization of iron from the slag or natural soils and rocks by water originating from the holding pond with a negative redox potential (Table 3.10). The negative redox potential is likely due to decaying vegetation within the holding pond sediment.

- Organics are isolated to one area of the site. An off-site source (i.e., above-ground storage tank seems to be the likely source.

6.10 Success of Meeting Objectives

During the investigations conducted at the site, the four main objectives of the Phase II Investigation have been satisfied. The nature and extent of suspected "hazardous substances", as defined in Section 101(14) of CERCLA, and as previously defined by the IEPA, have been characterized. The relationship between various industrial deposits (e.g., slag) and suspected "hazardous substances" has been evaluated. The relationship between the industrial deposits and water resources for the area has been established. All work has been performed in accordance with applicable requirements and standards established by the USEPA and the IEPA.

CONCLUSIONS AND RECOMMENDATIONS

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Concluding Statements

Based on the results of the studies and investigations and analysis of the historical data and information, the following conclusions may be drawn:

- Ground water from the site discharges to the alluvial flow system, which consists of surface water in the Little Vermilion River, as well as ground water in the alluvium.

- The holding pond system does not significantly contribute to ground-water flow (i.e., there is no appreciable leakage).

- Relatively minor impacts to ground water have been detected within the slag at the Carus Chemical Company.

- The organic constituents measured in the northeastern portion of the site are isolated. The source is believed to be located on the former M&H Zinc Company property and needs to be addressed by the current owner (LaSalle Rolling Mills) or the IEPA to prevent further impacts to ground water.

- The nature and extent of chemical constituents within the ground water, soils (including slag), the holding pond, and the Little Vermilion River have been sufficiently characterized. No further investigation of the Phase I and II Areas of the Carus Chemical Company property are warranted.

- The findings indicate that there are no immediate threats to human health or the environment; therefore no immediate response actions are warranted.

The conclusions of the Phase II Site Investigation support the conclusions set forth in the "*Technical Summary Report Supporting Separation of Carus Chemical Company Properties from Surrounding CERCLIS Site Activities*" [GeoSyntec, 1995], including the conclusions developed for the M&H Zinc Company site.

7.2 Recommendations for Further Action

7.2.1 Overview

As previously discussed, several environmental investigations have been performed by the IEPA and GeoSyntec at the Carus Chemical Company manufacturing facility. At present, the geology, hydrogeology, and constituent impacts to soil (including slag and sinter), ground water, the holding pond, and the Little Vermilion River are known. The following work may need to be performed:

- a risk assessment to assist in developing cleanup objectives for the site;
- evaluation of site measures appropriate to obtain cleanup objectives;
- selection and approval of site measures based on assessment of risks and a cost/benefit analysis, and design of an appropriate remedial system; and
- implementation of site measures approved by the IEPA.

This work is further discussed in Sections 7.2.2 through 7.2.4.

7.2.2 Risk Assessment

An assessment will be performed to evaluate the risks associated with leaving proposed levels (i.e., cleanup objectives) of contaminants in the soil. The risk assessment will be presented within the Site Measures Evaluation Report. IEPA and USEPA guidance documents will be utilized to perform the risk assessment, including the guidance currently under development by the IEPA. Other guidance documents may include the following:

- "*Risk Assessment Guidance for Superfund, Volume I; Human Health Evaluation Manual*" (EPA/540/1-89/002, December 1989);

- "*Risk Assessment Guidance for Superfund: Volume I - Part B, Development of Risk-Based Preliminary Remediation Goals*" (Pub. 9285.7-01B, December 1991);

- "*Human Health Evaluation Manual Supplemental Guidance: Standard Default Exposure Factors*" (Pub. 9285.6-03, March 1991);

- "*Superfund Exposure Assessment Manual*" (EPA/540/1-88/001, April 1988);

- "*Dermal Exposure Assessment: Principles and Applications*" (EPA/600/8-91/011B, January 1992;

- "*Exposure Factors Handbook*" (EPA/600/8-89/043, July 1989);

- "*Summary Report on Issues in Ecological Risk Assessments*" (EPA/625/3-91/018, February 1991);

- "*Ecological Assessment of Hazardous Waste Sites: A Field and Lab Reference*" (EPA/600/3-89/013, March 1989);

- "*Risk Assessment Guidance for Superfund, Volume II: Environmental Evaluation Manual (Interim Final)*" (EPA/540/1-89/001, March 1989);

- 35 Illinois Administrative Code, Part 620, Subpart F: Health Advisories;

- Integrated Risk Information System (IRIS); and

- Health Effects Assessment Summary Tables (HEAST).

7.2.3 Evaluation of Site Measures

An evaluation of viable site measures will be performed. The site measures evaluation will include assessment of measures based on:

- results of the risk assessment;
- ability to meet proposed cleanup objectives;
- reliability of system;
- proven track record in industry;
- applicability to site geology;
- effectiveness with the constituents of concern; and
- costs associated with construction, operation, and maintenance, and monitoring, if required.

The evaluation will include a recommendation for site measures. The work will be documented in the Site Measures Evaluation Report. The contents of this report will include, but not be limited to, the following: (i) results of the risk assessment; (ii) proposed cleanup objectives; (iii) evaluation of site measures; and (iv) recommended site measures to meet the proposed cleanup objectives.

7.2.4 Selection and Implementation of Site Measures

After IEPA approval of recommended cleanup objectives and site measures is received, the site measures design will be documented in a design report which will be submitted to the IEPA for approval. After approval is received, the site measures will be implemented.

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REFERENCES

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